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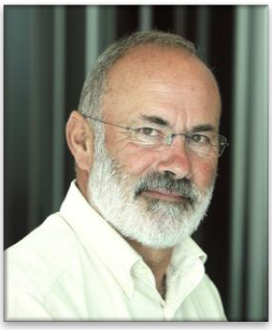
FOREWORD



Combining Science and Sport

The EHF is convinced that there is no discontinuity between abstract approaches and their concrete and practical implementation on court.

Sport, in general, and handball, in particular, needs to steep its roots in the fundamental soil of scientific knowledge, in order to progress in a controlled and responsible way towards the higher levels of performance in full respect of the individual performance.

Science needs to confront itself with the realities of the world around it, with the possible practical outcomes of its findings, with the dangers a misguided appropriation of its conclusions can produce.

It is, therefore, essential that a forum should be made available to all those concerned in the long chain of intellectual and practical responsibilities in the field of handball, so that we work in common, mutual understanding, and a clear preoccupation with the respect of the individual should prevail.

In 2011, the first Scientific Conference was organised by the European Handball Federation on the fringes of its 20th anniversary based on an initiative by Frantisek Taborsky, the former EHF Methods Commission Chairman, who also founded the EHF Union of University Handball Teachers (UUHT). The range of the scientific presentations was wide, including approaches from training sciences, human sciences and sport medicine.

The second edition followed in 2013, explicitly dealing with Women's Handball. In addition a medical mini symposium was held on the first day with the focus on knee injuries in women's handball that turned out to receive great attention.

The third edition this year will be fully dedicated to medical aspects of training and the game, touching on topics such as injury prevention and prophylactic training.

The EHF is both very grateful and honoured to receive support from ESSKA (European Society of Sport Traumatology, Surgery and Arthroscopy) that has taken over the patronage of this conference as well as medical experts from Israel (Lior Laver) and Denmark (Jesper Bencke), who have prepared the medical mini symposium as a starting point of this conference.

My personal wish is that we shall succeed in establishing a kind of medical platform of experts contributing to the sport of handball for the sake of the athletes' health and well-being in the future. Also Beach Handball, a new sport of incredible value inside the handball family, shall be made a topic of scientific research concerning medical and social aspects in the future.

Last but not least I would like to thank both the 2015 EHF Scientific Conference Organising Committee and the Romanian Handball Federation as the host of the event, at the same time wishing all the best to presenters and participants!

Prof. Jean Brihault
EHF President

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Notes by the Editor

* This book comprises of the full articles that were provided by the authors. A number of further articles and topics were presented at the Conference in Budapest but have not been submitted by their authors. Though the full version of those articles is not available in the present documentation, their abstracts can be found towards the end of the book, under “Further topics presented at the Scientific Conference”, (p. 137-164).

* For reasons of comprehension and/or grammatical coherence some of the article titles have been grammatically and/or syntactically altered, thus differing from the version submitted by the author.

* The articles are published as submitted by their authors. No grammatical or syntactical corrections have been implemented. Spelling also varies, based on the authors’ preferred form of English (British or American).

* To serve editing purposes, the outline form of some articles may have been altered. However, the content remains unaffected.

* A useful list of e-mail addresses of Conference presenters and/or article authors can be found at the end of this book.

COMPARATIVE STUDY OF METABOLIC DISORDER DUE TO HIGH INTENSITY TRAINING SESSIONS IN FIRST LEAGUE MEN AND WOMEN'S HANDBALL TEAMS

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Summary

The purpose of this study was to present and to analyze the biochemical changes that occur during high intensity handball training within 50 elite handball players – man and women. The mean age for mans players was 23 $\pm$ 3, 21 and for the women 22 $\pm$ 2, 23. The training protocol and structure was the same for both players categories and took place in their own training hall under our strictly observation.

Key words: *handball, biochemical changes, performance, training.*

Introduction

At the high performance handball training level the smallest details observation of the specific activity is realized now by compare some of the values of pulse, lactic acid concentration, heart rate or other physiological parameters which could show us the specific training area in which our handball players are acting (1, 2, 22.).

A physiological and biochemical approach of the specific handball effort is necessary because high performance in team handball means much more than a perfect technique or a perfect collaboration between players during technical–tactical combinations in the official competitions (5, 7, 8) .

A deeper understanding of the biochemical processes which are happened in the handball player body it could be a benefit for the future training structures conception, a correct evaluation of the individual resources for a handball player in critical moments of a competition or specific training structures adaptation, according to the permanent player demanding (24, 25, 26, 28).

Dynamic changing values of the pCO_2 in relation with blood pH and LA blood concentration values is a much more significant marker than LA blood concentration itself for performance; relation between SBC and HCO_3^- indicates metabolic disorders which take place during specific effort in handball, ABE values makes possible calculation of the LA blood concentration and shows the relation with other physiological parameters, others than VO_2max or breathing threshold as they are analyzed before (6, 11, 23) .

Methods:

Subjects:

Our research included 50 handball players (men) from 5 handball teams which are acted in the first Romanian League and 50 handball players (women) from 5 handball teams from the same performance level.

Approximately 150-200 microlitre of blood were necessary from middle finger of each player for biochemical determinations using ABL 5 Blood Gase Analizer. The samples were kept in a special frozen kit between the moment of testing and proper analyze at the "Lia Manoliu Sports Research Dpt. Center – Bucharest," where took place all the measurements and interpretations.

The signification of acid-base parameters which we have analyzed:

- pH sample – is measured by the pH electrode of the ABL 5, and indicates the acidity or alkalinity of the sample;
- pCO_2 (mmHg)– is measured by the pCO_2 electrode and is the carbon dioxide partial pressure (or tension) in a gas phase in equilibrium with the blood (3,4). High and low pCO_2 values of arterial blood indicate blood hypercapnia and hypocapnia, respectively;
- HCO_3^- sample (mmol/L) – is the concentration of hydrogen carbonate in the plasma of blood sample (also termed actual bicarbonate) and is calculated as stated in Eq.4;
- ABE (mmol/L) – Actual Base Excess, is the concentration of normal base when the blood is titrated with a strong base or acid to a plasma pH of 7.40 at the pCO_2 of 5,33kPa (40 mmHg) and 37^o C at the actual oxygen saturation (4,5); positive values (base excess) indicate a relative deficit of noncarbonic acids and negative values (base deficit) indicate a relative excess of noncarbonic acids;
- SBE (mmol/L) – Standard Base Excess, is an “in vivo”, expression of a base excess. It refers to a model of the extra cellular fluid (one part of blood is diluted by two parts of its own plasma) and is calculated using a standard value for the hemoglobin concentration of the total extra cellular fluid (including blood) of 3mmol/L as stated in Eq. 6;
- SBC (mmol/L) – Standard Bicarbonate, is the concentration of hydrogen carbonate in the plasma from blood which is equilibrated with a gas mixture with pCO_2 of 5,33kPa (40 mmHg) and pCO_2 > 13,33kPa (100 mmHg) at 37^o C(4,5) and calculated as stated in Eq. 7;
- LA blood concentration was calculated using the following formula :

$$LA = [(0,5 – ABE) \times 7,2] : 9,1 \text{ mmol/L};$$

- R – is the value of the relation between SBC and HCO_3^- (SBC / HCO_3^-), related to 1 values which is the normal in pause condition. Any variation up and down indicate breathing or metabolic disorders determined by the effort intensity;

Results:

Our research values are presented in Table1 and Table 2, for each 50 handball players men and women.

At the end of the experiment we found some statistical significant differences between the beginning and the end of the training at some of our tested biochemical parameters values. Our values indicates an aerobic field of action pointed with some anaerobic periods of effort especially at the men players but at the same time women were characterized by an aerobic effort even if the intensity of the effort during the training session were same as the competition (3, 9, 10). In our experimental conditions we don’t have any alkalosis state, because pH has only decreased evolution (12, 13).

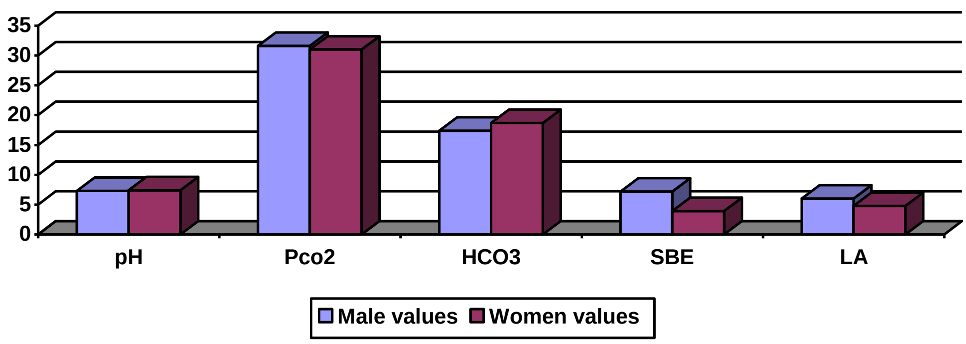
Table 1. *The dynamic of the metabolically parameters values after training sessions in male teams*

Metabolic parameters (average values)				
pH	PCO_2 (mmHg)	HCO_3 (mM/l)	SBE (mM/l)	LA mM/l
7.352 ± 0.008	31.600 ± 0.838	17.480 ± 0.580	- 7.260 ± 0.784	6.009 ± 0.407

Table 2. *The dynamic of the metabolically parameters values after training sessions in women teams*

Metabolic parameters (average values)				
pH	PCO_2 (mmHg)	HCO_3 (mM/l)	SBE (mM/l)	LA mM/l
7.403 ± 0.007	31.040 ± 0.547	18.740 ± 0.247	- 3.940 ± 0.231	4.811 ± 0.197

Graphic 1. *Comparative graphical representation of the studied metabolical parameters in both male and female teams*



Discussions

Even if the women teams has been characterized by an metabolic acidosis (determined by the evolution of the pH and pCO_2) the same acidosis status is present in men teams (but the compensated one), where we have in plus an increased lactic acid concentration (LA) in addition to 20% decreased plasma bicarbonate concentration (HCO_3^-). The interpretation scale has take in considering Sigaard Anderson nomogram for determination of the acidosis or alkalosis players specific status (21, 22, 23).

According to our results we can appreciate that in men teams after training session pH, pCO_2 , HCO_3^-, ABE, SBE and SBC values are decrease, during the statistically significant increased LA blood concentration. At the women teams are the same modifications but with different limits. The modifications induced by the intensive specific effort determine the following effects (14):

- respiratory acidosis;
- respiratory alkalosis;
- metabolic acidosis;
- metabolic alkalosis;

In our experimental conditions we found no alkalosis status after training, pH has only decrease tendency. On the other hand, the increased values of the plasmatic pCO_2 (because of the hypoventilation) represent the main cause of the decreasing pH values and the respiratory acidosis appearance. The extra cellular increasedpCO_2 values will be accompanied by the increasing H_2CO_3 values (H_2CO_3 as a result of hydrated CO_2) which will be dissociate in H^+ and $H_2CO_3^-$, but as the buffering capacity will be out of control the pH value will decrease faster.

The respiratory acidosis in one of the most common cause of the basic – acid disorders. Even a few minutes hypoventilation could cause an acidosis status with pH values of 7,0. In this situations the plasma and spinal cord liquid chemoreceptor will appreciate the plasmatic pCO_2 and excess of the CO_2 it will be eliminate by the hyperventilation induced. If the pulmonary response is not present the kidney response will occur through the increasing secretions of H^+ inside the tubular liquid. Even with intervention of the kidney activity, the recovery of the normal pH values is not possible without any respiratory and circulatory support. Our experimental data shows a plasmatic decreased pH and pCO_2 values because of the effort stimuli during the training session so we can say that a metabolic acidosis is installed. According to that it is well-known that the main cause of the metabolic acidosis is organic acids high accumulation. The (H_2CO_3 - HCO_3^-) buffer system it is exceeded by the organic acids H^+ releasing ions and so the pH values start to decrease.

In this experiment (in male teams for instance), post training LA has increased approximately 4 times (from 1,67± 0,244 mmol/L to 6,0 ± 0,407 mmol/L), plasmatic bicarbonates decreased 20% approximately (from 22,12 ± 0,518 mmol/L to 17,48 ± 0,58 mmol/L) and 31,6 ± 0,838 mmHg pCO_2 post training values determine a compensated metabolic acidosis status, (normal rest values of pCO_2 it is 35 - 45 mmHg in men and 32 – 42 mmHg in women) (14, 27).

The LA concentrations could increase in this situation as a result of the stimulated Sympathetic Nervous System because of specific effort characteristics induced by the hormonal activity. The specific activity of catecholamine could be a cause of the increased LA blood concentration (4, 15, 17, 18).

All of this data shows a different kinds of specific effort reactiveness in men and women teams, depending of the level of their own training capacity (19,20). Using the same training structures at the same intensity during training, it could be a benefit for the handball players, both men and women, only in case that the performance level is close enough, and the physiological, biochemical and even psychological profile of the handball players are included in approximately same limits (16, 17).

Conclusion

The level of high performance training in handball could be appreciate in small details taking in considering evolution of this biochemical parameters values. According to that, we will point the followings:

- even if pH values are controlled by buffering systems, an untrained person could not perform any physical activity with 7,0 value of this parameter; our handball players as the others athletes could perform for a short period of time physical activity at 6,9 and even lower pH values;
- pCO_2 is an essential parameter because is very unstable during training conditions; in normal conditions the higher pCO_2 values are accompanied by lower values of pH; in untrained persons or not very well trained athletes the relation between this two parameters is different, lower values of pCO_2 are accompanied by the lower pH values; that s why is necessary to point that in high performance athletes, the lower pH values are not accompanied by increased or decreased values of pCO_2 , the pCO_2 values has to be closed to the normal rest values; very important to mention, the smaller pCO_2 values difference between beginning and finishing training program we have, the higher performance athletes capacity is possible;
- ABE parameter is necessary for LA blood concentration calculation; LA has to be analyzed according to pCO_2 values, because the same value of LA blood concentration has a different signification when it is accompanied by two different pCO_2 values (e.g. 22mmol/L , LA blood concentration with pCO_2 = 34 mmHg means that our athlete has a good shape and could perform a higher intense effort and if this 22mmol/L is accompanied by pCO_2 = 24 mmHg, means that our athlete it is completely exhausted with a very important body metabolic disorder; this difference of pCO_2 values could be translated as a 1000m altitude training place for this two athletes);
- The relation between SBC and HCO_3^- has an important signification because is the main metabolic disorder marker; if it is appreciate according with the other parameters values will tell us much more about the physiological and biochemical handball player profile;
- At the highest level of handball performance is good to know that ***acid-base concentration organic disorder produced by the blood concentration of H_2CO_3 has a respiratory origin*** and at the same time, when we found an ***acid-base concentration organic disorder produced by the blood concentration of HCO_3^- this has a metabolic origin.***

REFERENCES

1. Acsinte A. - Handball - International guidelines, Alma Mater, Bacau, 2009;
2. Acsinte A., Alexandru E. - Physical condition in high performance team handball (requirements), Vienna/Austria- Publisher, EHF Web Periodical, ISSN 1560-3067, 2007;
3. Alm A., Tornquist P. (1985) – Lactate transport through the blood-retnal and blood-brain barrier in rats. Ophtalmic res, 17, 181-184;
4. Ahmaidi S., Hardy J.M, Varray A., Collomp K., Mercier J., Préfaut C. (1992) – Relation entre le seuil d'accumulation du lactate et le seuil de l'inadaption ventilatoire a la production de CO_2 au cours d'une epreuve d'exercice musculaire chez le sportif, Science and Sports, 7:157-162;
5. Christensen N., Galbo H. (1983) – Sympathetic nervous activity during exercise, Ann. Rev. Physiol. 45: 139;
6. Hamilton A.L., Nevill M.E., Brooks S., Williams C. (1996) – Physiological responses to maximal intermittent exercise: differences between endurance trained runners and games players, Journal of Sports Sciences, 9: 371-382;
7. Harnish C.R. (2001) – Methods for Estimating the maximal lactate steady state in trained cyclist, Med. Sci. Sports Exerc., 33:999-1005
8. Helgerud J., Engen L.C., Wisloff U., Hoff J. (2001) – Aerobic endurance training improves soccer performance, Med. Sci. Sports Exerc., 33:1925-1931
9. Hoff J. (2002) – Soccer specific aerobic endurance trainings, British Journal of Sports Medicine, 36; 218-221.
10. Lucia D. (2002) – Lactix acidosis potasium and heart rate deflection point in professional road cyclists,, British Journal of Sports Medicine, 36; 113-117.
11. Maffulli N. (1991) – Indices of sustained aerobic power in young middle distance runners. Med Sci Sports Exerc, 23: 1090-1096;
12. Martin M.C., Duvallet A., Rieu M. (1996) – État stable de la lactatemie lors de l'effort submaximal sur tapis roulant, Science and Sports, 11: 166-172;
13. Martini F. H. (2001) – Fundamentals of anatomy and physiology, Prentice Hall, New Jersey;
14. Mazzeo R.S. (1991) – Arterial catecholamine responses during exercise with accute and chronic high altitude exposure. Am J Physiol Endocrinol Metab, 261: e419-e424;
15. Olff M. (1991) – Defense and Coping: Self reported health and psychological corelates. Doctoral thesis. University of Utrecht. Nederlands;
16. Podolin D.A. (1991) – Plasma catecholamine and lactate response during graded exercise with varied glycogen conditions. J Appl Physiol, 71: 427-433;
17. Sargent C., Scroop G.C., Nemeth P.M., Burnet R.B., Buckley J.D. (2002) – Maximal oxygen uptake and lactate metabolism are normal in chronic fatigue syndrome, Med. Sci. Sports Exerc., 34: 51-56
18. Selye H. (1936) – A syndrome produced by diverse nocuous agents, Nature, 138, 22;
19. Selye H. (1974) – Stress without distress, J.B. Lipincott, Philadelphia;
20. Siggard-Andersen O. (1963) – Blood acid-base alignement nomogram. Scales of pH, Pco_2, base excess, of whole blood of different hemoglobin concentrations, plasma bicarbonate and plasma total CO_2. Scand. J. Clin. Lab. Invest. 15, 211.
21. Siggard-Andersen O. (1962) – The pH, log Pco_2 blood acid-base nomogram revised. Scand. J. Clin. Lab. Invest. 14, 598.
22. Siggaard-Anderson O. (1966) – The Acid-Base Status of the Blood. Ed. Munksgard, Coppenhagen
23. Simon J. (1983) – Lactate accumulation relative to the anaerobic and respiratory compesation thresholds. J Appl Physiol, 54;

THE EFFECTS OF 6-WEEK CREEPING EXERCISE PROGRAM ON STATIC STRENGTH IN YOUNG HANDBALL PLAYERS

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Summary

The purpose of this study was to determine the effects of a specifically designed 6-week biweekly creeping workout program on static strength in young handball players. The study included 28 handball players aged between 7 and 11 years. They were randomly divided into two sub-groups, the experimental group and the control group. Their initial and final state of static upper-body (arm and shoulder girdle), lower limbs and core strength was measured with seven motor tests. The experimental group significantly improved their result in several tests.

Key Words: young handball players, creeping, static strength.

Introduction

The result in Handball match depends on many factors, among which, already in younger age groups, strength is very important. Strength is manifested in almost all the elements of handball game: in jumping, sprinting, landing, when performing passes, in various shots, changes the direction of movement and at stopping and holding of an opponent (Sibila, 2004).

Choosing the appropriate training content is, when planning the development of strength in the senior age category, fairly well defined, as there is a wide choice of methods and means which favourably affect the progress of the various manifestations of strength in adult handball players. It is, of course, necessary to consider certain rules concerning appropriate quantity and exercise intensity. But it's important to start with a coherent and efficient development of strength in handball players much earlier.

In the past it was considered that strength training for younger age groups does not produce the desired results and can even be dangerous, and cause disturbances in growth (Pierce, Byrd & Stone, 1999). Recent research suggests that it was a wrong conviction. But models of exercise for adults should not be transfer to children and adolescents training, but they should be adapted to the developmental stage of the child. Among others, strength training should be interesting and varied to maintain the motivation of children to exercise thus to avoid decreasing in intensity.

Therefore, the approach to strength training in young handball players must be undertaken in a planned and thoughtful manner. It's necessary to consider biological order in growing up. Natural forms of movement could be considered as one of the most suitable means for developing strength in youth age categories, since these phylogenetically developed movements are appearing in everyday life, and are therefore familiar to children (Pori, 2007).

In particular, various forms of creeping should be taken into account, while they affect the muscles of legs, arms, shoulder girdle and torso, i.e. body segments, which are very exposed in handball. Creeping is human locomotion in a support position (front or back support position) where weight is on hands and feet, torso is raised-up from floor. Locomotion is executed with a help of arms and legs. In comparison with crawling, in creeping there is less friction due to the torso raised from the ground. But they can also be energetically demanding as crawling, because the movement can be considerably faster. Loads that reach around 40% of maximum muscle strain may be elicited already with the basic forms of creeping. But if more advanced versions are used, load may also reach 90% of maximum muscle strain (Pistotnik, Pinter & Dolenec, 2002). In the training creeping and crawling may be included as a separate mean or as a part of elementary games.

On the basis of the above mentioned facts the purpose of this study was to determine the effects of a specifically designed 6-week biweekly creeping workout program on static strength in young handball players.

Methods

Sample

The study included 28 handball players aged between 7 and 11 years. They were randomly divided into two sub-groups, the experimental group and the control group -14 players in each group. The average age of the control group was 9,2 ± 1,2 and the average age of the experimental group was,9,56 ± 1,0 year.

Variables

Initial and final state of static arm, shoulder girdle, leg and torso strength was measured with seven motor tests.

Table1

Sample of variables

Test	**Measured capacity**	**Measuring unit**
Flexed arm-hang	static arm and shoulder strength	Seconds
Side plank on Right forearm	static torso strength	Seconds
Side plank on Left forearm	static torso strength	Seconds
Isometric back extension	static torso strength	Seconds
Isometric crunch	static torso strength	Seconds
Isometric wall squat on Right leg	static leg strength	Seconds
Isometric wall squat on Left leg	static leg strength	Seconds

In Table 1 all variables are presented. One test is dedicated for measuring the static arm and shoulder strength, four tests for static torso strength and two for static leg strength. All tests were summarized by various authors and are described in the literature (Mackenzie 2005; Jakovljevič & Kacin, 2011; Korošec, 2013).

Data analysis

The data were analysed using the statistical package SPSS 20.0. Basic parameters of the distribution of variables were calculated (mean, standard deviation, minimum and maximum values). Changes between initial and final measurements were determined by Student’s paired t-test. A probability level of 0.01 or less and 0.05 or less was taken to indicate significance.

Procedure

Both groups performed the initial and final testing. The experimental group performed a 6-week, twice a week creeping workout program between the initial and final testing (Table 2). Difficulty of exercise is escalated every week with concerning amount and the mode of a creeping. Rest between the series was 1,5 minute and rest between exercises 2,5 minute.

Table 2: *Content of 6-week biweekly workout program of creeping*

Week	Nr. of units	Type of creeping	Nr. of series	Distance (m)
1	2	A	3	10
		B	2	10
2	2	C	3	10
		D	3	10
3	2	E	2	10
		B	3	10
4	2	F	2	10
		E	3	10
5	2	G	3	12
		B	3	10
6	2	F	3	12
		G	3	12

Notes: A - Front Support Position, moving forward ("walk on all fours"); B - Back Support Position – moving backwards ("Crab walk"); C - Front Support Position, moving backwards; D - Back Support Position – moving forward; E - Front Support Position, moving forward by dragging feet behind ("Seal walk"); F - Back Support Position, moving backwards by dragging feet behind ("Seal walk"); G - Front Support Position, with the raised legs and partner supporting the thigh ("the wheelbarrow").

Results

Table 3 presents the basic statistical characteristics of all measured parameters obtained at the initial and final measurement for experimental group. The table shows average values, standard deviations, minimum and maximum values and significance of Student's paired t-test.

Table 3: *Basic statistical characteristics of all parameters on initial and final measurements and significance of Student's paired t-test for experimental group*

	Initial measurements				**Final measurements**				
Parameter	$\bar{x}$	**s**	**min**	**max**	$\bar{x}$	**S**	**min**	**max**	**P**
Flexed arm-hang	29,1	19	4,7	78,7	33,2	20,9	5,2	90,0	<0.01
Side plank on Right forearm	57,0	25,1	14,6	96,2	59,9	22,4	19,5	100	>0.05
Side plank on Left forearm	50,1	18,4	20,1	86,2	55,5	18,7	22,5	88,5	<0.01
Isometric back extension	80,,0	36,8	42,1	180,3	82,1	28,7	45,3	154,2	<0.05
Isometric crunch	56,6	,18	32,4	85,9	64,1	17,8	37,1	91,5	>0.01
Isometric wall squat on Right leg	21,6	10,5	6,5	40,2	21,9	7,9	7,9	35,4	>0.05
Isometric wall squat on Left leg	19,9	9,1	5,7	39,0	21,9	8,7	9,4	34,6	>0.05

Note. $\bar{x}$ *- Average values; s - standard deviations; min – minimum values; max - maximum value; P – significance of Student's paired t-test.*

Table 4: *Basic statistical characteristics of all parameters on initial and final measurements and significance of Student's paired t-test for control group*

	Initial measurements				Final measurements				
Parameter	$\bar{x}$	**s**	**min**	**max**	$\bar{x}$	**s**	**min**	**max**	**P**
Flexed arm-hang	17,8	8,8	5,6	33,8	17,2	8,2	3,6	31,9	>0.05
Side plank on Right forearm	35,6	17,9	8,9	72,3	33,8	15,8	8,8	57,9	>0.05
Side plank on Left forearm	35,3	15,9	16,2	72,1	35,9	17,4	12,8	73,8	>0.05
Isometric back extension	50,5	16,7	37,1	100,9	50,6	12,9	33,9	78,2	>0.05
Isometric crunch	51,1	26,3	20,0	99,2	50,4	23,4	20,2	90,5	>0.05
Isometric wall squat on Right leg	22,0	15,5	7,2	58,3	21,4	11,7	8,9	43,4	>0.05
Isometric wall squat on Left leg	17,8	11,4	5,1	43,2	18,0	8,3	7,0	30,9	>0.05

Note. $\bar{x}$ *- Average values; s - standard deviations; min – minimum values; max - maximum value; P – significance of Student's paired t-test.*

Table 4 presents the basic statistical characteristics of all measured parameters obtained at the initial and final measurement for control group. The table shows average values, standard deviations, minimum and maximum values and significance of Student's paired t-test.

Discussion and Conclusions

Results of our study indicate that experimental group significantly improved their results in three out of seven tests. In tests Side plank on Right forearm, Isometric back extension, Isometric wall squat on Right leg and Isometric wall squat on Left leg there was no significant improvement. Significant improvement was achieved in tests Flexed arm-hang, Side plank on Left forearm and Isometric crunch. If we take into consideration percentage of improvement, the highest average value was recorded at the flexed arm-hang test – 19.5%, followed by the isometric crunch test – 16.6% and by the side plank on the left forearm test with 12.7% improvement. On the contrary no statistically significant differences were observed in control group.

We may conclude from our study that supplementary 6-week creeping workout program in young handball player's increases static upper-body and core muscles strength. Unfortunately, training creeping, as we have conceived, did not affect the progress of the static strength of the leg muscles. The creeping movement structure was probably insufficiently dedicated to legs and players mainly used arm and shoulder girdle muscles and torso for successful performance in motor tasks. This means that we should also include a type of creeping, where it is important to work the legs. Probably we should we say that progress in strength was mainly attributed to neurological adaptations, which are most pronounced in the early stages of training, while in this period optimization of intra-muscular coordination by agonists, synergists and stabilizers occur. Folland and Williams (2007, as cited in Behm et al., 2008) speculated that the contribution of neurological adaptation depends on the level of preparedness of an individual prior to start with a workout.

This shows that in children who are less prepared/experienced than adults, this contribution is larger and faster. Falk and Tenenbaum (1996) report that strength by pre-pubertal children increased for 13-30% during a special designed strength program which lasted 8-20 weeks. In many other researches it was proven that children may improve their strength during a well planed training. Improvement of strength for 30-40 % was recorded by children who participated in 8-12 week strength training program. Even 6-years old children benefit from strength training.

In pre-puberty period there is no evidence about differences in strength between boys and girls (Earle & Baechle, 2004). By our entities the improvement was slightly lower, but it was probably due to relatively short duration of the experiment. Based on the results we can speculate that larger improvement in strength could be achieved if training duration would increase. That's why creeping was long ago proposed as one of the most appropriate training mean to enhance strength by handball players in age from 7 to 10 years (Pori, Luzar & Šibila, 2010). The contemporary lifestyle of children with a lot of seating and limited possibilities for spontaneous play and carrying out other motor activities (eg. climbing on the trees) has led to a reduction of strength in children. It's very important, that already in children, coaches dedicate enough attention on development of this motor skill. By doing this some principles should be followed: children must be supervised and corrected in exercising in the way that exercises are performed technically correct; activities must be designed in such a way that all children are active; in exercising it is necessary to avoid monotony (Earle & Baechle, 2004).

Furthermore, for optimal effect of exercising strength in children it's necessary to consider some other rules: it is necessary to ensure a safe and enjoyable training environment; an adequate warm-up is important before starting with strength exercises; recommended are 2-3 training units per week; strength training should not be performed in consecutive days; various parts of the body should be involved in exercising (whole body); it is necessary to take into account the gradualness of motor tasks – load should increases gradually with increment of strength (Faigenbaum et al., 1996). Creeping can be also largely utilized in the development of strength in the older age categories, while introduce other, particularly more intensive means of strength training (Pori, Luzar & Šibila, 2010).

References

Behm, G. D., Faigenbaum, A. D., Falk, B. Klentrou, P. (2008). Canadian Society for Exercise Physiology position paper: resistance training in children and adolescents. *Appl. Physio.l Nutr. Metab. 33,* 547-561.

Earle, R. W. &, Baechle, T. R. (2004). *NSCA's essentials of personal training*. Champaign, IL: Human Kinetics.

Faigenbaum, A.D., Kraemer, W. J., Cahill, B., Chandler, J., Dziados, J., Elfrink, L. D., … Roberts, S. (1996). Youth resistance training: NSCA Position Statement Paper and Literature Review. *Strength and Conditioning, 18*(6), 62-75.

Falk, B., & Tenenbaum, G. (1996). The effectiveness of resistance training in children: A metaanalysis. *Sports Medicine*, 176-186.

Fratina, R. (2011). *Vpliv vadbe lazenja na moč rok* [Effects of creeping exercises on the strength of arms. In Slovenian.]. (Bachelor's thesis). Ljubljana: Fakulteta za šport

Mackenzie, B. (2005). *101 Performance Evaluation Tests*. London: Eletric World.

Pierce, K. C., Byrd, R., & Stone, M. H. (1999). Youth weightlifting – is it safe? *Weightlifting USA, 17*(4), 5.

Pistotnik, B., Pinter, S. & Dolenec, M. (2002). *Gibalna abeceda*. [Physical exercise alphabet. In Slovenian.]. Ljubljana: Fakulteta za šport.

Pori, P. (2007). Naravne oblike gibanja kot sredstvo razvoja moči mladih rokometašev (1. del – plazenja in lazenja). [Natural forms of movement as a means of developing strength in young handball players (1. Part – creeping and crawling). In Slovenian.]. *Trener rokomet, 14*(1), 17-23.

Pori, P., Luzar, K., & Šibila, M. (2010). Uvajanje otrok in mladostnikov v vadbo z utežmi. [Introducing children and adolescents in Weight Training. In Slovenian.]. Trener rokomet, 17(2), 25-30.

Šibila, M. (2004). *Rokomet: izbrana poglavja.* [Handball: Selected Chapters. 2nd revised ed. In Slovenian.]. Ljubljana: Univerza v Ljubljani, Fakulteta za šport.

INFLUENCE OF HANDBALLS WITH DIFFERENT WEIGHTS ON OVERARM THROWING

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Summary

The throwing movement of adolescent male handball players was analysed using handballs with different weights. Ball velocity and relevant kinematic parameters were influenced by balls heavier than 550 g (i. e. velocity of elbow extension and internal shoulder rotation), but no general influence of weight on relative and absolute timing could be found.

Keywords: ball velocity, joint angles, angular velocity

Introduction

Ball velocity is an important factor of handball performance. Relevant kinematic parameters for high ball velocities are maximal angular velocities in elbow extension and internal shoulder rotation as well as optimal timing of these parameters (van den Tillaar & Ettema, 2004; Wagner, Buchecker, von Duvillard, & Müller, 2010). Improving ball velocity is a potential aim in handball training. Throwing exercises using lighter and heavier balls represent an opportunity to improve ball velocity regarding sport specific movements (DeRenne, Ho, & Murphy, 2001; Edwards van Muijen, Jöris, Kemper, & van Ingen Schenau, 1991; van den Tillaar, 2004). For successful training interventions, one prerequisite would be that the ball weights do not change the movement pattern negatively (Müller, 1982). However, no results of ball velocity and kinematics, i. e. the movement pattern, of adolescent (national) handball players are available depending on a stepwise weight variation from lighter (300 g) to heavier handballs (800 g) in contrast to the standard ball (450 g) with the same ball size (ball size 3).

Methods

Twelve male adolescent national handball players (17.3 ± 1.2 years, handball experience 11.6 ± 2.5 years) participated in a study with a three-dimensional movement analysis (for the kinematic model see Wagner, Pfusterschmied, von Duvillard, & Müller, 2011). The subjects performed standing throws without run-up with different weighted handballs (ball size 3). The distance to the target was 4 m; the target was a square (1*1 m) in the lower half of a handball goal (see Figure 1). Ball velocity after ball release was measured by a high-speed video camera (Basler AG) on the right hand side, calibrated to the position of the throwing hand when releasing the ball.

The eleven balls differed only in weight from 300 g to 800 g in 50 g steps and were produced by Kempa® (Balingen, Germany) with the same characteristics as the standard handball. The subjects threw three times with any of the balls in randomized order. The sequence from the reverse point to ball release was analysed regarding changes in kinematic parameters of the upper body and the throwing arm (maximal joint angles and maximal angular velocity with time of occurrence relative to ball release).

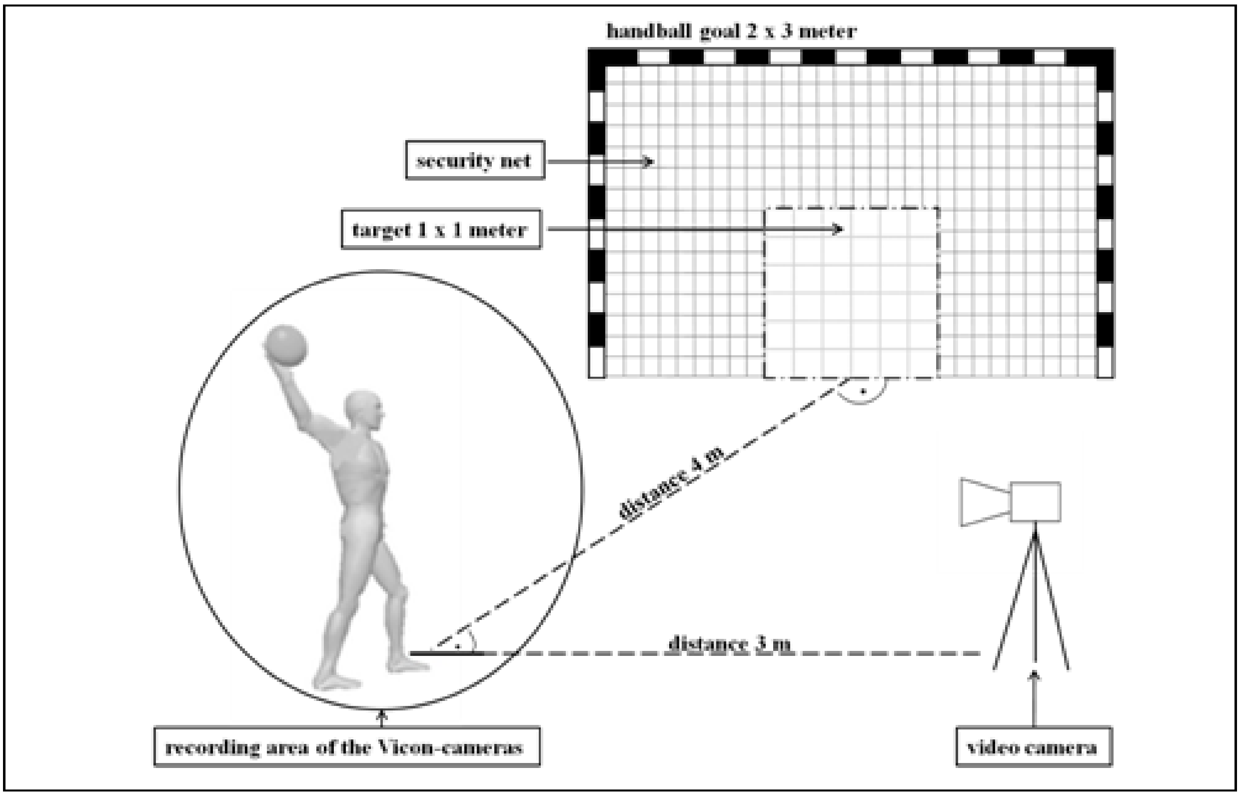

Figure 1: *Experimental Setting*

Results

Throwing the standard handball (450 g) the players reached an average ball velocity of 83.5 km/h (±5 km/h). With the heavier balls (550 g and more) the players produced significantly lower velocities (at least 5 km/h or more; see Figure 2) but a higher average impulse (mass*velocity; see Figure 3). On the contrary, with lighter balls (300 g and 350 g) the players reached significantly higher velocities and lower impulses (see Figure 2 and 3).

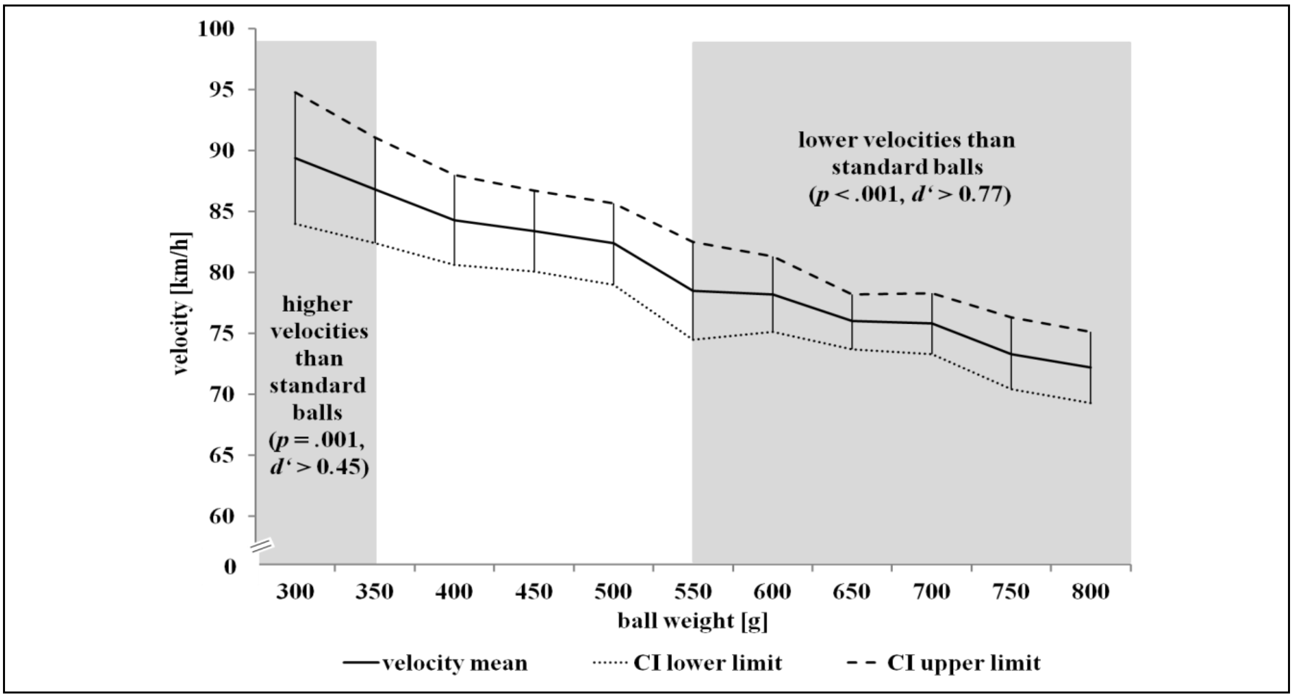

Figure 2: *Ball velocity dependent on different ball weights (mean and CI 95%)*

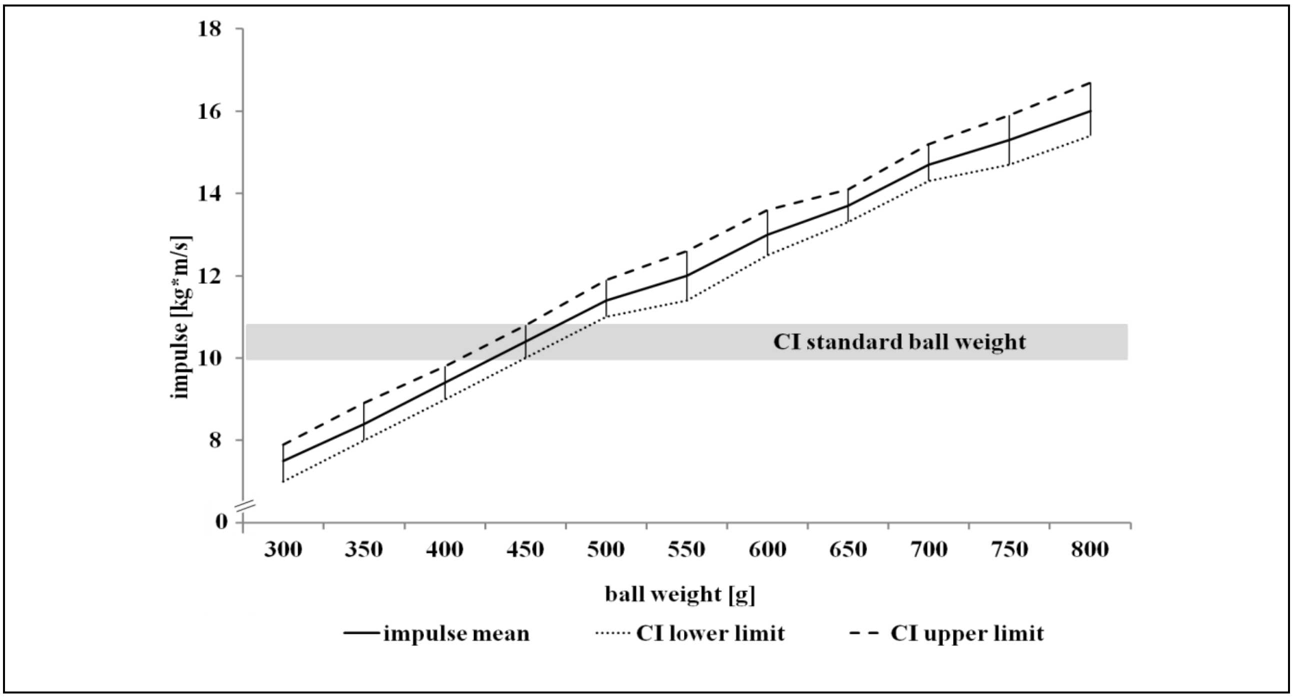

Figure 3: *Impulse dependent on different ball weights (mean and CI 95%)*

The different weights did not influence the maximal joint angles but relevant maximal angular velocities (elbow extension: $F(3.6, 39.6) = 7.0$, $p < .001$, $\eta^2_p = .39$, df corrected by $\varepsilon_{GG} = .36$; internal shoulder rotation: $F(4.1, 44.8) = 5.7$, $p < .001$, $\eta^2_p = .34$, df corrected by $\varepsilon_{GG} = .41$). Lower maximal angular velocities for elbow extension in contrast to the standard ball could be found for the ball weight 550 g ($t[11] = 2.59$, $p = .025$, $d' = 0.34$), and all heavier balls. The internal shoulder rotation reached lower maximal velocities in contrast to the standard ball when throwing with the 800 g ball ($t[11] = 4.06$, $p = .002$, $d' = 0.60$).

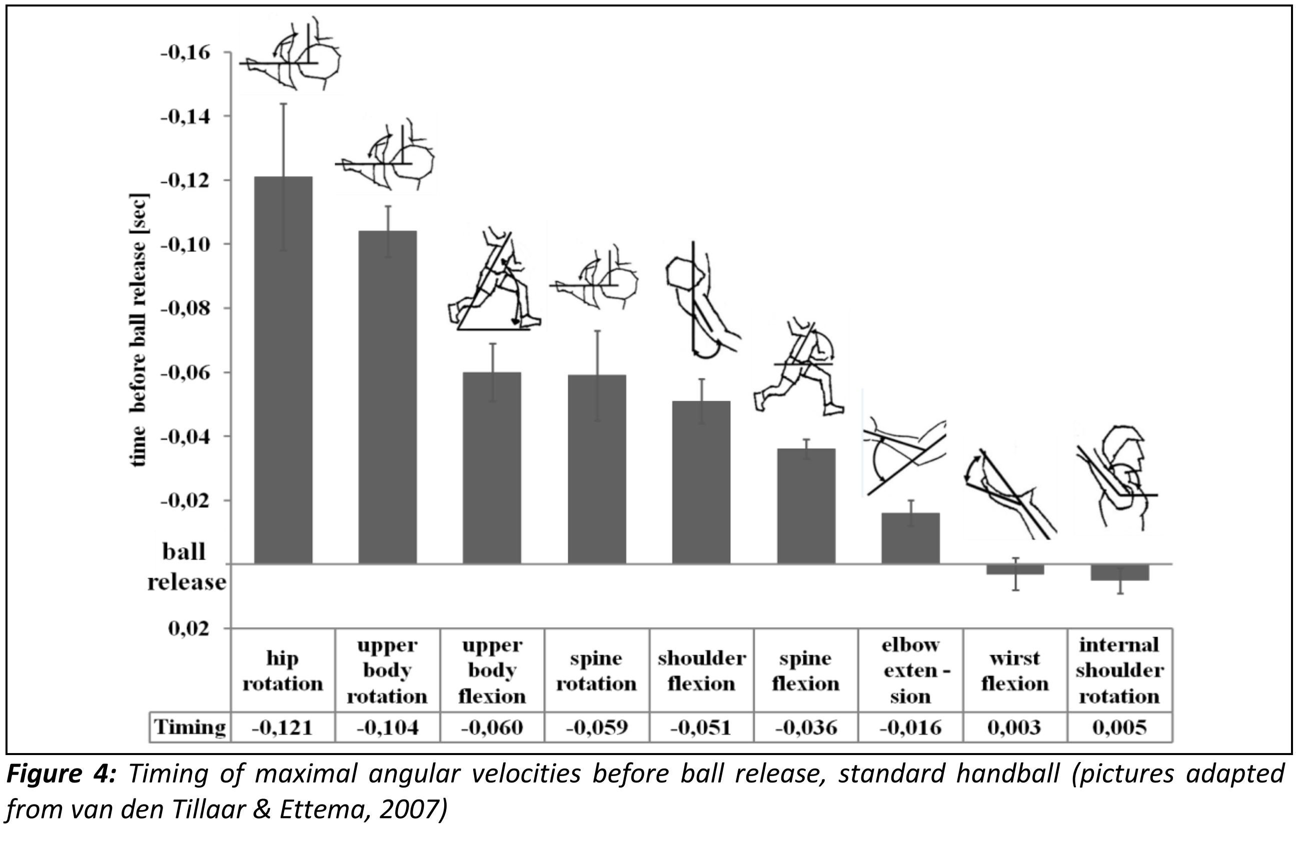

Figure 4: *Timing of maximal angular velocities before ball release, standard handball (pictures adapted from van den Tillaar & Ettema, 2007)*

The relative timing of maximal angular velocity did not change over the different ball weights (for example see Figure 4). The absolute timing only changed significantly in parameters that reached the maximal velocity on average after ball release (i. e. wrist flexion and internal shoulder rotation), but only to a small extent.

Discussion and practical implications

Compared to the results when throwing standard balls, ball velocity differed for balls heavier than 550 g and lighter than 350 g. Relevant throwing kinematics were generally influenced by balls heavier than 550 g (i. e. maximal angular velocity of elbow extension and internal shoulder rotation), but the ball weights had no impact on the movement pattern of throwing (i. e. absolute and relative timing). The 800 g ball might be too heavy because of the changes in relevant maximal angular velocities (i. e. elbow extension and internal shoulder rotation).

The 550 g ball seems to be the cut-off weight for the adolescent male handball players. Before administering 550 g balls in regular training situations we will examine whether throwing exercises with this ball weight result in a higher ball velocity with the standard ball. Additionally, we prepare training interventions with the lighter ball weight (350 g) to examine the second approach of improving ball velocity with the standard ball.

References

DeRenne, C., Ho, K. W., & Murphy, J. C. (2001). Effects of general, special, and specific resistance training on throwing velocity in baseball: a brief review. *Journal of Strength and Conditioning Research, 15*(1), 148-156.

Edwards van Muijen, A. J., Jöris, H. J., Kemper, H. C., & van Ingen Schenau, G. J. (1991). Throwing practice with different ball weights: effects on throwing velocity and muscle strength in female handball players. *Sports Training, Medicine and Rehabilitation, 2*, 103-113.

Müller, E. (1982). Zur Bewegungsübertragung bei Wurfbewegungen - Eine biokinematische und elektromyographische Analyse von Wurfbewegungen mit Handbällen. *Leistungssport, 12*(4), 314-324.

van den Tillaar, R. (2004). Effect of different training programs on the velocity of overarm throwing: a brief review. *Journal of Strength and Conditioning Research, 18*(2), 388-396.

van den Tillaar, R., & Ettema, G. (2004). A force-velocity relationship and coordination patterns in overarm throwing. *Journal of Sports Science and Medicine, 3*, 211-219.

van den Tillaar, R., & Ettema, G. (2007). A three-dimensional analysis of overarm throwing in experienced handball players. *Journal of Applied Biomechanics, 23*, 12-19.

Wagner, H., Buchecker, M., von Duvillard, S. P., & Müller, E. (2010). Kinematic description of elite vs. low level players in team-handball jump throw. *Journal of Sports Science and Medicine, 9*, 15-23.

Wagner, H., Pfusterschmied, J., von Duvillard, S. P., & Müller, E. (2011). Performance and kinematics of various throwing techniques in team-handball. *Journal of Sports Science and Medicine, 10*, 73-80.

A MORNING PREWORKOUT EFFECT ON MUSCLE FATIGUE
AN EFFECT STUDY ON MUSCLE FATIGUE 6 HOURS AFTER HEAVY RESISTANCE TRAINING

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SUMMARY

Studies show that a preworkout with heavy resistance training enhances physical performance in the afternoon. No scientific literature shows if this effect influences muscle fatigue. To determine which effect a morning preworkout that consist of heavy resistance training has on muscle fatigue in 20 countermovement jump 6 hours later, and what influence it has on the jumping height for elite athletes aged 15-18 years.

KEYWORDS

Heavy resistance training, muscle fatigue, countermovement jump, preworkout, elite athletes

INTRODUCTION

The physical requirements for an elite athlete has been increased therefore they need to perform at their max. Resistance training has become an important part of the training for many athletes. During many years as elite athletes it is our experience that many do not train heavy resistance before their performance. On that account we got curious when we read the article written by Cook (2014) in Journal in Science and Medicine in Sport with the name "Morning based strength training improves afternoon physical performance in rugby union players.

The article created an increased interest because of its different view on the lead up to physical performance. They present the idea that heavy resistance training six hours before performance can boost the level of testosterone and cortisol and thereby improve the physical performance level seen by semi-professional rugby players. 3 groups consisting a control-, a sprint- and a heavy resistance group were tested for a week.

On the testing days the control group should relax, the sprint group should sprint and the weight training group should do squats and bench press. On the same day all groups turned up for afternoon testing. The tests consist sprint, CounterMovementJump, squat and bench press. The heavy resistance training in the morning created improvements in all tests. The background search resulted in more studies which demonstrated that preworkout consisting heavy resistance training could improve the physical performance later in the day.

Ekstrand (2013) has presented a test where 14 athletic practitioners in the throwing disciplines, should train heavy resistance and then be tested after 4-6 hours later in the day. The tests consisted of backward overhead shot throw (BOST) and vertical jump. Next the results were analysed and compared to a control test where the same 14 athletes didn't do heavy resistance training in the morning. The conclusion was that the BOST performance was significantly better when the 14 athletes had been training heavy resistance in the morning - but there were no significant difference between the groups concerning vertical jump.

Furthermore there are more studies which show that heavy resistance training before vertical jump has no effect on vertical jump or postactivation potentiation (Chaouachi et al. 2011). No studies prove that this effect has influence on the muscle fatigue if the players jump more than 3 times. To determine which effect a morning preworkout, that consist of heavy resistance training, has on muscle fatigue in 20 countermovement jump 6 hours later, and what influence it has on the jumping height for elite athletes aged 15-18 years. We made a pilot study and from that a paired CT-study.

METHODS

Pilot study

Before the testing period a pilot study was performed. The purpose of this pilot study was to standardise the testing protocol before the actual data collection. This was done in order to find possible errors and defects which could have influenced the final results and in order to achieve safety in the use of data collection equipment and to raise the intra reliability. After different setups (20, 50, 70 jumps) the pilot study showed that 20 jumps resulted in the best design for the test. At this number all participants did try to maximize their jumps each time.

Design

In a paired CT-study (Clinical controlled trial) conducted on 7 elite athletes over 2 weeks the participants switched between a preworkout and non-preworkout. The preworkout consist of heavy resistance training in 3 RM back squat at 8.00h and testing in countermovement jump at 15.00 h. Non-preworkout consists of no training and testing in countermovement jump at 15.00h. The test persons have to perform preworkout consisting heavy resistance training at 8.00-9.00 o' clock and should be tested after 6 hours at 14.20-15.40 o' clock

Test persons

The testing group consists of five male and two female elite athletes. Our intervention- and control group consists of the same seven persons and they are all to be subjected to the same intervention. The control group has to restitute the whole day before being tested later in the day. They are allowed to go to work but they cannot do any heavy resistance training or any active recovery. The intervention group has to perform heavy resistance training six hours before the test. The heavy resistance training will consist of the exercise back squat. The exercise are to be performed with 3 repetitions of 3 sets respectively 80-90-100% of 3 RM.

DEVELOPMENT

In this bachelor project there are seven test persons. Six of these are handball players and one is a badminton player. Out of these two are female and five are male. On the basis of the factual information about height, weight, age and amount of exercise/training the population is described as follows:

Mean±SD, age: 16±1year; height: 1,83±0,07 m; weight: 75±7 kg,
On average they exercise 9±1,5 hours per week and has been exercising squat for 2,7 ±1,3 years.
The collected information for the entire test course has been analysed and discussed and will be presented in the following paragraphs.

Dropout analysis

Six test persons completed the test/study. One person had to drop out after the first week due to illness. It is not considered that the test person dropped out because of the intervention. The collection of information concerning the test person who dropped out will still be part of the statistical analysis. Instead of using an average from the first and the second week - the measurements from the first week will be used.

Result of countermovement jump test

Table 1 - Show the results of T-Test for fatigue index with non-preworkout compared to preworkout.

Table 1 – T-test for Fatigue index				
Test person	Fatigue index in % for non-preworkout	Fatigue index in % for preworkout	Difference in %	How many % less fatigued
1	0,948	9,639	-8,691	-916,457
2	6,680	4,633	2,048	30,654
3	14,160	9,827	4,334	30,603
4	11,834	9,386	2,448	20,682
5	4,932	13,645	-8,713	-176,676
6	3,138	-3,171	6,310	201,050
7	8,304	-0,697	9,001	108,394
Mean of fatigue index	7,142	6,180	0,962	13,472
Standarddiviation	4,344	5,712		
Konfidensinterval	3,218	4,232		
Shapiro-Wilks test:	p = 0.925	p = 0.359		
p-værdi	0,729			

On the basis of table 1 there are no significant difference concerning fatigue between non-preworkout and preworkout.

On the basis of the high p-value 0,7289 it is indicated that there are no increased fatigue during the 20 CMJ when a morning preworkout has been performed. On average the test persons are fatigued by 13,5% less, when they have performed a preworkout

Table 2 *- Shows the result of the T-Test concerning the last jump with non-preworkout compared to first jump with preworkout.*

Tabel 2 - T-test last jump			
Test person	Non-preworkout in cm	Preworkout in cm	Difference in cm
1	28,995	29,352	-0,357
2	36,327	38,633	-2,306
3	32,305	33,861	-1,555
4	33,582	35,529	-1,948
5	40,049	37,544	2,505
6	39,610	42,164	-2,554
7	36,862	39,881	-3,019
Mean of jump height	35,390	36,709	-1,319
Standarddiviation	3,708	3,925	
konfidens interval	2,747	2,908	
Shapiro-Wilks test:	p = 0.734	p = 0.921	
p-værdi	0,1140		

Table 2 doesn't show a significant difference between non-preworkout and preworkout. The P-value of 0,1140 indicated that days with preworkout result in a higher last jump than days with nonpreworkout.

On average the test persons jump 3,7% higher by the last jump when they have performed a preworkout which corresponds to 1,32 centimeters.

DISCUSSION

In this bachelor project seven male and female elite athletes participated. The number of test persons are to low to generalise on young elite athletes. In order to generalise and see tendencies it should have been tested on a representative number of elite athletes aged 15-18 years. This would have given a wider picture of the of the correlation between preworkout and performance level six hours later. Despite the low number of test persons the project do describe something which is not presented in current litteratur.

The difference in the fatigue index for the test persons after preworkout did not show significant compared to nonpreworkout. This means that there has been no fatigue. Out of seven participants two are more fatigued and five are less fatigued after preworkout. Out of the five who have less fatigued - two have improved their jumping height after 20 jumps. On average the test persons are 13,5% less fatigued after morning heavy resistance training. In sport this is a notable effect to add in because every improvement can mean the difference between winning or losing. The relatively high dispersal in the result 7,1424 ±4,3443 on non-preworkout and 6,1802 ±5,7121 after preworkout has to be considered. This indicates that less fatigue occurs after preworkout but further studies with more test persons are needed in order to reduce the confidence interval and to obtain adequate safety degree.

Table 2 shows a difference on 3,7% between non-preworkout and preworkout at the last jump of the 20 CMJ. It is not significant but a P-value on 0,1140 shows that this could be interesting to study further. The numbers in table 2 show that six of out seven test persons have improved their jumping height at the last jump compared to non-preworkout. This means that 86% have had a positive effect of preworkout

In our study, we have subsequently been able to see possible bias that may have had a influence on the results of our study, if we are to follow up on our study, it is factors such as, the temperature in the test room and the age of the test persons, we would have to standardize. Another example on a possible bias, is that the test persons changed from focusing on weightlifting with their respective teams, to focusing on drills in the sports hall within the testing period. It should also have been described in our test protocol.

CONCLUSION

In this study the effect of a morning preworkout consisting heavy resistance training leads to 13,5% less fatigue for the test persons in general and they jump **3,7 %/1,32 centimeter** higher in their last jump. The results suggest that a preworkout does not increase muscle fatigue in 20-countermovement jump. Because of the uncertainties and limitations the results cannot be concluded with certainty, and additional research in this area is needed.

REFERENCE

Chaouachi, A., Poulos, N., Abed, F., Turki, O., Brughelli, M., Chamari, K., Drinkwater, E.J. & Behm, D.G. 2011, "Volume, intensity, and timing of muscle power potentiation are variable", *Applied physiology, nutrition, and metabolism = Physiologie appliquee, nutrition et metabolisme,* vol. 36, no. 5, pp. 736-747.

Cook, C.J., Kilduff, L.P., Crewther, B.T., Beaven, M. & West, D.J. 2014, "Morning based strength training improves afternoon physical performance in rugby union players", *Journal of science and medicine in sport / Sports Medicine Australia,* vol. 17, no. 3, pp. 317-321.

Ekstrand, L.G., Battaglini, C.L., Mcmurray, R.G. & Shields, E.W. 2013, "Assessing explosive power production using the backward overhead shot throw and the effects of morning resistance exercise on afternoon performance", *Journal of Strength and Conditioning Research,* vol. 27, no. 1, pp. 101-106.

MOUTHGUARD USAGE AMONG JAPANESE COLLEGIATE HANDBALL PLAYERS

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SUMMARY

The purpose of this study was to investigate the extent of mouthguard use and the attitudes toward mouthguards among collegiate handball players participated in the spring league 2015 of the Kyusyu Collegiate Handball Association. Although many of the players had experienced oro-dental injuries, the players hardly used mouthguards. The findings suggested that it should be required for collegiate players including younger players to be promoted sufficient information about oro-dental injuries and mouthguards.

Keywords: handball, mouthguard, collegiate players, questionnaire

INTRODUCTION

For decades, handball has been an activity program of physical education (PE) at Japanese schools, such as soccer and basketball. It has promoted various benefits for students, but it has also led to many incidents. Oro-dental injury would be common among sports-related injuries. More than 17,000 oro-dental injuries due to both PE program and sports at Japanese schools were reported only in 2012 (Japan Sport Council. 2012). Handball, in terms of injury incidence, was the third highest sport behind rugby and basketball at Japanese schools (Sugimoto H. 2014).

A number of researches have shown that protective equipment such as properly fitted mouthguards is effective to reduce the number and the severity of orofacial injuries. In addition, the American Dental Association and the International Academy for Sports Dentistry recommend using mouthguards to players in contact sports including handball. Some Japanese associations of the contact sports such as ice-hockey, boxing and lacrosse have required that players use mouthguards during the game, as the Japan Rugby Football Union has mandated the use of mouthguards for u-15 and u-19 players since 2006. Other Japanese sports associations such as soccer and basketball have remained indicating the guideline for using mouthguards.

The Japan Handball Association gives the players leave to use mouthguards, yet the prescription regarding a mouthguard cannot be seen in the rulebook. It has still not been widely accepted to use mouthguards in contacts sports in Japan. It requires more effort in clarifying barriers to mouthguard use to increase acceptance of it. However, the extent and the awareness of mouthguard use during handball are unclear in Japan. This study was undertaken to investigate the experience of oro-dental injuries, mouthguard usage and attitudes toward mouthguard use among Japanese collegiate handball players.

METHODS

Subjects: The subjects selected for the present study were collegiate handball players participated in the spring league 2015 of the Kyusyu Collegiate Handball Association. Questionnaire packages including a cover letter explaining the purpose of the study and the way of collecting the questionnaire were distributed to the student representatives of each team at the first meeting during the league with oral explanation of them. 226 players (46%), out of a total of 486 players registered for the league, agreed and returned the questionnaires. 223 questionnaires (45%) were analyzed. The subjects consisted of 144 males and 79 females.

Measurements: The questionnaire was developed with the survey form concerning a mouthguard of the Japanese Academy of Sports Dentistry. The questionnaire measured demographic information on the players, the history of oro-dental injury, the extent of using mouthguards (table.1) and the attitudes toward mouthguard use (table.2). It was not likely that the use of mouthguards was widespread among handball players in Japan, therefore it was expected that most of the subjects had not used mouthguards ordinarily.

The questionnaire was attempted to evaluate the extent of using mouthguards in detail. Following The Transtheoretical Model (Prochaska & DiClemente, 1983), the extent of using mouthguards was categorized into 6 groups; no concern to use mouthguards (Stage 0), no intention to use mouthguards with some concern (Stage 1), intention to use mouthguards within the next 6 months (Stage 2), intention to use mouthguards within this 1 month (Stage 3), using mouthguards in the past 6 months (Stage 4) and using mouthguards over 6 months (Stage 5).

Table 1 Stages of mouthguard use

Stage 0; I have no concern with using mouthguards
Stage 1; I have no intention to use mouthguards with some concern
Stage 2; I intend to use mouthguards within the next 6 months.
Stage 3; I intend to use mouthguards within this 1 month.
Stage 4; I have used mouthguards within the past 6 months.
Stage 5; I have used mouthguards over 6 months.

The attitudes toward mouthguard use were investigated for the players of Stage 1 to Stage 5 because it was expected that it likely to be difficult for Stage 0 players to respond.

Table 2 Items to measure the attitudes toward mouthguard use

What is (would be) your difficulty in using mouthguards, (if you used)?	
- I (would) feel pain or pressure in teeth.	Y/N
- I (would) feel pain or pressure in gums.	Y/N
- I (would) feel pain or pressure in jaw.	Y/N
- I (would) look bad .	Y/N
- I (would) feel difficulty in braething.	Y/N
- I (would) feel difficulty in biting.	Y/N
- I (would) feel difficulty in speaking.	Y/N
- I (would) feel some foreign body.	Y/N
- I (would) feel nauseous.	Y/N
- It (would) costs a lot.	Y/N

The data was calculated statistically by using chi-square analysis, with $p<0.05$ as statistical significance. The Statistical Package for Social Sciences (version 21.0 Statistical Base, SPSS, Inc., Chicago, IL, USA).

RESULTS and DISCUSSION

88.8% of the players (n=198) were not concerned with mouthguard use. 10.3% of the players (n=23), who had some concern, did not intend to use mouthguards. 0.4% of the players (n=1) intended to use mouthguards within the next 6 months. 0.4% of the players (n=1) had used mouthguards the last few months. Almost all of the players would not use mouthguards. This might reflect that no teammate used mouthguards. Jaccard et al. suggested that adolescents' behavior were influenced by their close friends' behavior (Jaccard et al. 2005). Moreover, there is little chance to see that someone uses mouthguards during handball games in Japan. A person's belief about whether most people approve or disapprove of the behavior influences behavioral intention (Ajzen, 1991). The results indicated that mouthguard use would be hardly popularized for Japanese handball players.

Table 3 Mouthguard usage among players

Stage of mouthguard use	No. of players		
	male (n=144)	female (n=79)	total (n=223)
Stage 0; I have no concern with using mouthguards	123	75	198
Stage 1; I have no intention to use mouthguards with some concern	20	3	23
Stage 2; I intend to use mouthguards within the next 6 months.	1	0	1
Stage 3; I intend to use mouthguards within this 1 month.	0	0	0
Stage 4; I have used mouthguards within the past 6 months.	0	1	1
Stage 5; I have used mouthguards over 6 months.	0	0	0

Table 4 shows mouthguard use by injury. There was not a significant difference in mouthguard use between injured players and non-injured players (χ^2=1.39, df=1, p=0.42). 42.2% of the players (n=94) had experienced oro-dental injuries. The results indicated that oro-dental injuries did not motive the handball players to use mouthguards. This might be because the players have not been educated about the potential harm of oro-dental injuries and the benefits of mouthguards. Yamada et al. suggest that soccer has been considered a sport unnecessary to use mouthguards in Japan (Yamada et al. 1998). It was suggested that the players had considered handball as a sport necessary to use mouthguartds as well, even though handball was still a high risk sport.

Table 4 Mouthguard use in relation to oro-dental injury

	Use of mouthguard (n and %)		Chi-square	P value
	Yes	No		
Injured	1 (0.4)	93 (41.7)	1.39	0.42
Not injured	0 (0)	129 (57.8)	(df=1)	

df, degrees of freedom

Table 5 shows the attitudes toward mouthguard use. The players felt or expected that mouthguard use caused feeling some foreign body (64%), difficulty in breathing (44%), difficulty in speaking (32%), the cost (32%), bad appearance (28%), pain and pressure in teeth (16%), pain and pressure in gums (16%), pain and pressure in jaw (12%), difficulty in biting (12%) and feeling nauseous (12%). The results indicated the players already had negative attitudes toward mouthguard use despite lack of experience. Also, the results suggested that the players would not choose custom-made mouthguards. David et al. reported that it could solve problems, such as difficulty in breathing and speaking, caused by improperly fitted mouthguards to start using custom-made mouthguard at early period of career (David et al. 2005). However, Japanese adolescents have few opportunities to be educated about mouthguards at their schools. Moreover, the players were anxious with the cost of mouthguard use. These suggest parents' support would be an important role to make custom-made mouthguards used widely.

Table 5 Attitudes to mouthguard use

	No. of players (n= 25; players categorized into Stage 1 to 5)
Some foreign body	16
Difficulty in breathing	11
Difficulty in speaking	8
Cost	8
Bad appearance	7
Pain and pressure in teeth	4
Pain and pressure in gums	4
Pain and pressure in jaw	3
Difficulty in biting	3
Nausea	3

CONCLUSION

The results of the present study found that most of collegiate handball players had no concern with mouthguards and negative attitudes toward mouthguard use, even though many of them had experienced oro-dental injuries. This is likely due to lack of information regarding oro-dental injuries and mouthguards. Handball in Japan is a contact sport which does not have mandatory mouthguard regulations. It should be required for collegiate players including younger players to be educated about the potential harm of oro-dental injuries and the benefits of mouthguard use.

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COMPARATIVE ANALYSIS OF THE KNEE INJURIES IN SPORTS GAMES

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Summary

The large number of lesions at the knee articulation resulted from sports injuries is a constant in the studies. Sports injuries at the knee articulation are accompanied by long periods of recovery and they can let morphological and functional sequelae, with consequences on the activity of sports and on the personal and social life - only in conditions which are not diagnosed in time and treated properly.

Keywords: Injuries, Articulation, Knee, Sports Games

Introduction

During the practice of the sports games there are a multitude of possibilities for injury. Known accident location over time as follows:

- Hands and fingers - 14%
- Ankle - 10%
- Knee - 7%
- Elbow - 5%.

The remaining 64% of locations are listed as different, because more than half of them are localized as muscle or tendinous contusion. In terms of severity, which converge the numbers have the following values:

- 48% are contusion,
- 36% sprains;
- 8% distorsions and fractures
- 8% muscle or tendon rupture and wounds.

Traumatic risk (6), as a concept, takes into account the intensity there are practiced the sports games (number of hours per week) and the number of years of practice. Various investigations have revealed two essential factors of risk: physical engagement and level of attention.

Physical engagement, more or less violent, it is based on:
- Sex - girls occur twice less injuries;
- The playing level - three times less injuries in the Premier League that in the second league, due to the different number of hours of training;
- The position held.

The level of attention

The hour of games and training sessions. On time interval 19-20 are three times more accidents than other hour intervals. In this period is manifested most strongly the syndrome of hypoglycemia.

The number of substitution. It has been noticed that there is a direct relationship between the number of substitution and the number of injuries. The number of accidents increases with the number of substitution. Is not important that the number of reserves is high, but the players from the bench have to be prepared to take part at the competition.

The absence of physical contact. The absence of an opponent or a teammate nearby determines a decrease of attention level. Approximately 60% of knee injuries occur in the absence of physical contact, and half of serious injuries occur in the absence of physical contact with an opponent or a teammate.

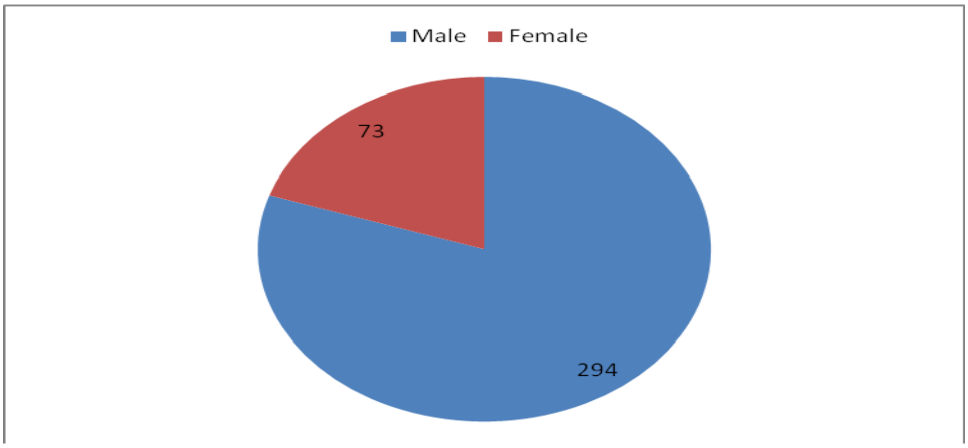
Methods

This study is based on the study of diseases anatomoclinical of the knee injuries in sports pathology. For this study, the diagnosis was established using clinical examination and imagery methods of investigation. Among these methods are: methods that uses X-rays and other radiation types (simple radiography and computed tomography and X-rays) and methods that not used (magnetic resonance imaging and ultrasound). The study is retrospective and aims to analyze the incidence of sports knee injuries, including statistical data from observation of the polling sheets Orthopaedic Bucharest Emergency Hospital between 2010-2014. The study included 367 patients with knee articulation trauma, practicing team sports (volleyball, basketball, handball, football).

Development

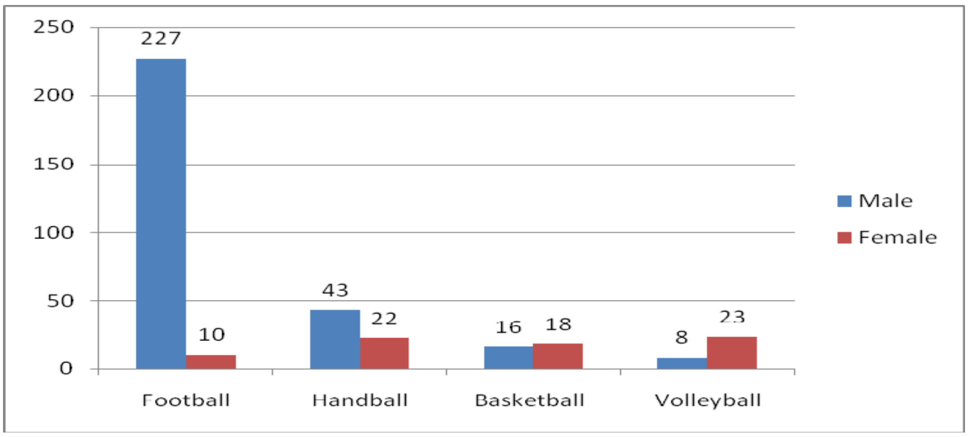
Of the 367 enrolled patients, 294 were male and 73 female, a ratio of 4: 1 male patients compared to female patients.

Chart 1 *– Patiens enrolled in the study*



Distribution of athletes in sports games and sex is as follows:

Chart 2 - *Distribution of athletes in sports games and sex*



Next we divided the athletes according to the main types of injuries, the sports game and sex the knee injuries.

***Chart 3 –** Cruciate ligaments injuries*

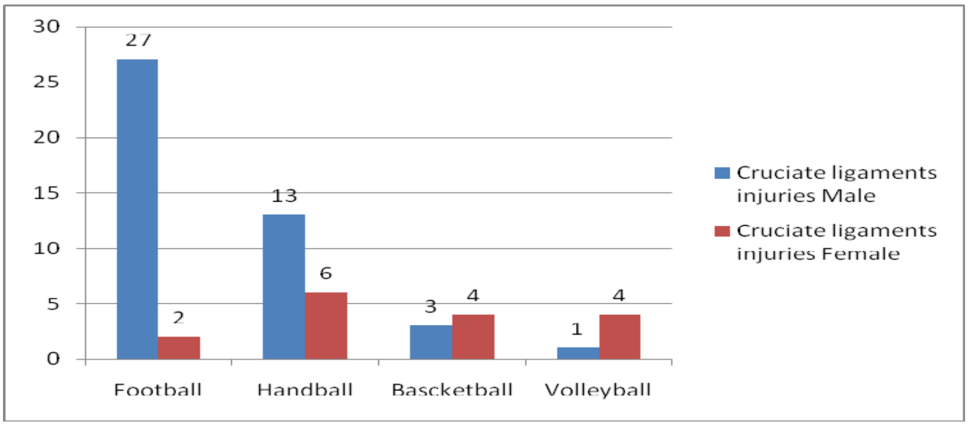


Chart 4 – Collateral ligaments injuries

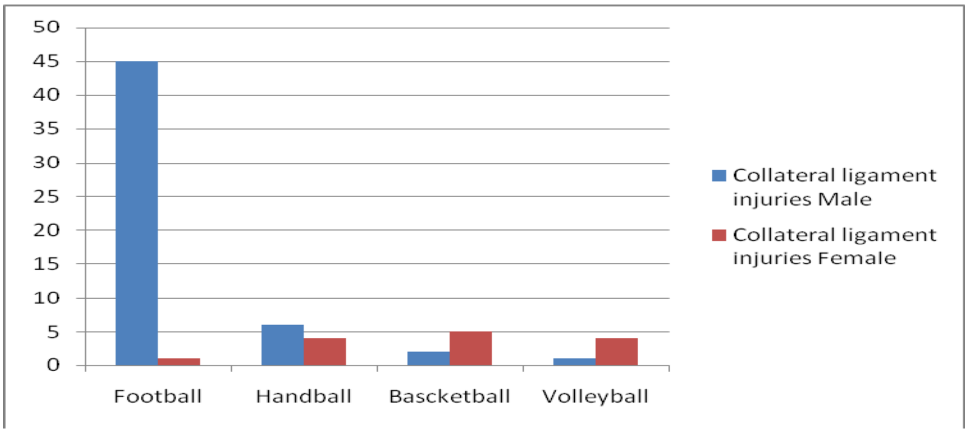


Chart 5 – Meniscal injuries

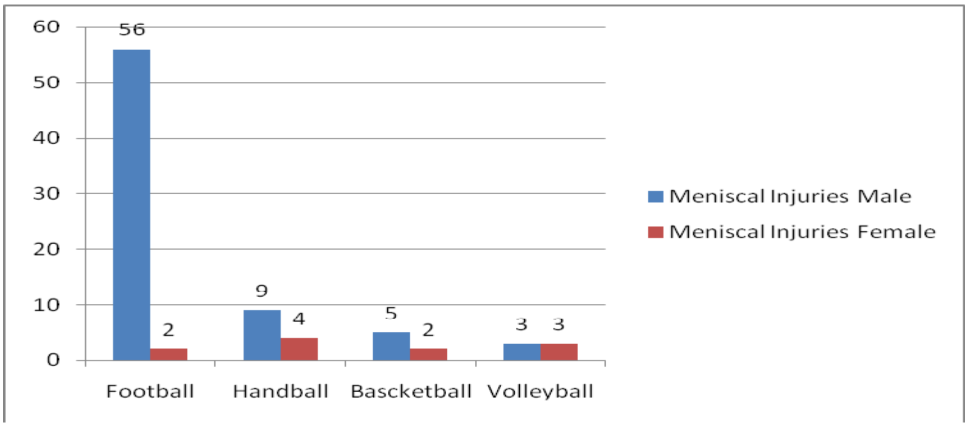


Chart 6 – Dislocation of the patella

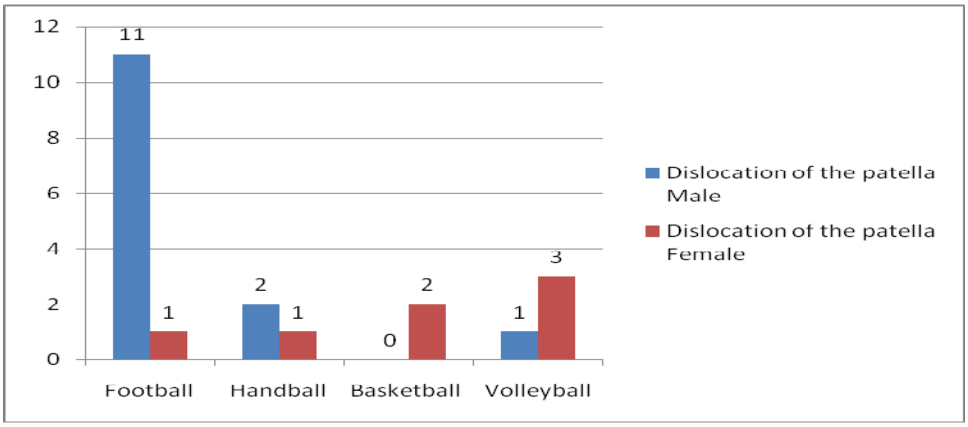
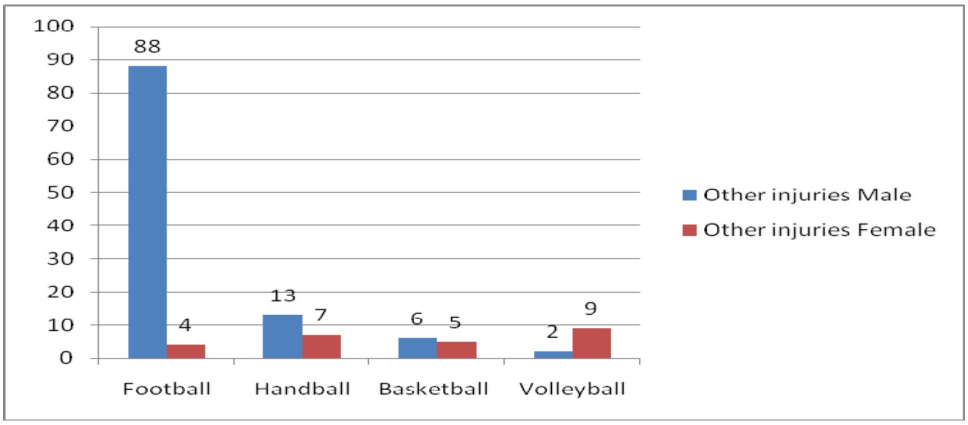


Chart 7 – Other injuries



Conclusion

Although the incidence of lesions in the knee joint is greater in women for 3 of the 6 included in the study sports (basketball, volleyball, gymnastics), the global incidence is significantly higher in men than in women. As stated by DE Loes (3), this may be due to the large number of practitioners of football and handball, men compared to women, both high-risk sports injuries production followed in the present study. The two sports are responsible for 75% of all cases included in the study. The study results are consistent with those presented by De Loes in 1995 1997 2000 (3,4,5) Backs in 1991 (2) Kujala et al. 1995 (9), Arendt and Dick 1995 (1), Myklebust et al. 1997 (10), Hutchinson and Ireland 1995 (8). Increased vulnerability for cruciate ligament injuries to basketball and volleyball for female have been reported by many authors (1, 3, 5, 7, 8, 10, 11, 12) and was confirmed by the current study. In a review of literature on the knee injuries injuries, Arendt & Dick (1995) (1) discussed the intrinsic factors (ligamentous laxity, leg alignment, size pin holes and ligaments) or extrinsic (body movements during sports activity, muscle strength, coordination of movement, the interface ground-shoes, conditioning, experience and individual aptitude) that cause such diseases. They concluded that the increased risk of developing injuries for cruciate ligament to female athletes have a multifactorial determinism without a single morphological or biomechanics condition, and it is likely that the primary mechanism is not caused by the contact between players. This is worth taking into account especially that most of these sports involve hard contact between players. Thus, we conclude that violence common in team sports can not be a crucial mechanism in producing in the knee articulation injuries to sports. Moreover, these sports are characterized by high risk of the lesion are characterized by increased travel speed and sudden changes of direction, which can be rather incriminated in causing such injuries.

Refrences

1. Arendt E, Dick R. Knee injury patterns among men and women in collegiate basketball and soccer. Am J Sports Med 1995: 6: 694–701.
2. Backs FJ, Beijer HJ, Bol E, Erich WB. Injuries in high-risk persons and high risk sports. A longitudinal study of 1818 school children. Am J Sports Med 1991: 19: 124–30.
3. De Loes M, Dahlstedt LJ, Thomee R, A 7 year study on risks and costs of knee injuries in male and female youth participants in 12 sports, Scandinavian Journal of Medicine & Science in sports,2000, 10 (2):90-97
4. De Loes M. Epidemiology of sports injuries in the Swiss organization and prevention of skiing injuries. Ann 73–82. ''Youth and Sports'' 1987–89. Injuries, exposure and risks of main diagnosis. Int J Sports Med 1995: 16: 134–8
5. De Loes M. Exposure data. Why are they needed? Sports Med 1997: 3: 172–5 studiu 1
6. Hantău C, Handbal – Noţiuni de bază, Ed. ASE, Bucureşti, pg. 97 - 100
7. Hippe M, Flint A, Lee RK. University basketball injuries: a five-year study of women's and men's varsity teams. Scand J Med Sci Sports 1993: 3: 117– 21.
8. Hutchinson MR, Ireland ML. Knee injuries in female athletes. Sports Med 1995: 4: 288–302
9. Kujala UM, Taimela S, Antti-Poika I, Orava S, Tuominen R, Myllynen P. Acute injuries in soccer, ice hockey, volleyball, basketball, judo, and karate: analysis of national registry data. BMJ: 311: 1465–8
10. Myklebust G, Maehlum S, Engebretsen Strand T, Solheim E. Registration of cruciate ligament injuries in Norwegian top level team handball. Scand J Med Sci Sports 1997: 7: 289–92.
11. Rohrl S, Hauser W, Schaff P, Rosemeyer B. Verletzungsmuster beim Skifahren weltweit. Knnen die derzeitigen Einstelleinrichtungen die Verletzungen in Zukunft reduzieren? (Pattern of injuries in skiing worldwide. Can current guidelines for adjusting ski bindings reduce injuries in the future?) Sportverletzung Sportschaden 1994: 2: 73–82.
12. Roos H, Ornell M, Ga¨rdsell P, Lohmander LS, Lindstrand A. Soccer after anterior cruciate ligament injuries - an incompatible combination? A national survey of incidence and risk factors and a 7-year follow-up of 310 players. Acta Orthop Scand 1995: 2: 107–12

ASSOCIATION OF A NEW AGILITY HANDBALL TEST, SPECIFIC SKILLS AND SELECTED MUSCULAR EXPLOSIVE PERFORMANCE OF LOWER LIMBS IN ADOLESCENT HANDBALL PLAYERS

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ABSTRACT

Handball performance is related more to velocity, agility, strength, explosive power, and the ability to repeat brief supra-maximal bouts of exercise than to either ball-handling skills or the capacity for sustained sub-maximal mechanical (Karcher and Buchheit, 2014). The aim of this study was to evaluate the association between a new handball agility test (HAT) and the selected explosive performance measurements of lower limbs in adolescent handball players.

KEYWORDS: Skills, muscular performance, agility test, lowers limb, handball players

INTRODUCTION

The ability to rapidly change direction and react to different stimuli in short distance is a particularly important requisite in team handball (Young et al. 2002; Sheppard et al. 2006). The capacity of handball players to produce varied agility and speed actions is known to impact handball match performance (Buchheit et al. 2009). Also, the high performance in various change of direction (COD) tests in handball players, compared with both the general population and the higher standards of handball, indicates that COD and agility attributes are advantageous for elite handball players (Chaouachi et al. 2009).The COD actions during handball competition can be categorized into actions requiring acceleration, maximal speed, or agility. Agility it is often recognized as the ability to change direction and start and stop quickly (Young et al. 2002).

Considering the importance of repetitive explosive actions and winning challenges in handball, the talent identification process usually involves a physical (i.e., anthropometry) and physiological (i.e., performance measures as speed, strength, aerobic and anaerobic power) testing battery relevant to the demands of the handball activity. However, the dimensional approach in talent identification based on physical and physiological parameters can be misleading.

An important issue is that excellence in handball is not dependent on one standard set of skills, but can be achieved in unique ways through different combinations of abilities. It has been suggested that variables such as high COD abilities may also be of importance in talent identification and development in youth selection (Visnapuu et al. 2009). However, there has been no study so far that could show the contribution of these capacities in young handball players while using of the new handball agility test (HAT) as protocol comprehends actions from some of the physical capacities above. We hypothesized that the HAT would have a stronger relationship with sport specific skills and muscular explosive determinants of low limb in young handball players.

METHODS

Participants

Thirteen youth handball players (15.8±0.7 years, body mass: 62.2 ± 09 kg; height: 1.69 ± 0.22m; percentage body fat: 11.6 ± 1.1 %;) were recruited from a center handball team, under conditions approved by the Institutional Review Committee for the ethical use of human subjects, in accordance with current national and international laws and regulations. Parental / guardian consent for subjects under 16 years old was obtained. The study was approved by the local research ethics committee and conformed to the recommendations of the Declaration of Helsinki.

Procedures

The new handball agility test (HAT). This zigzag test was chosen and modified in HAT using a short course four 5-m sections set out at 100° angles because it required acceleration, deceleration, and balance control facets of agility and also dribbling a ball with the hand (figure1) (i.e. activities that characterize match play in younger team handball) (Visnapuu et al. 2009). The familiarity of the subjects with the test and its relative simplicity also meant that we expect the learning effects to be minimal. Tests were conducted in this order: agility test with dribbling ball and without dribbling ball. Subjects performed two trials of each test, with at least 2 minutes of rest between all trials and tests. Electronic timing gates were used to record test completion times (Microgate Race time 2 Light Radio, Bolzano, Italy). The best performances in each test were used for analysis. All tests were conducted at least 48 hours after a competition or hard physical training to minimize the influence of fatigue on test performance.

Squat (SJ) and countermovement jump (CMJ) tests were determined using a force plate (Quattro Jump, version 1.04, Kistler Instrument AG, Winterthur, Switzerland). Jump height was determined as the center of mass displacement, calculated from the recorded force and body mass. For the SJ, subjects started at a knee angle of 90 degrees, were instructed to avoid any downward movement, and then performed a vertical jump by extending upwards, keeping their legs straight throughout the jump. The CMJ started from an upright position, making a rapid downward movement to a knee angle of ~90 degrees and simultaneously beginning to push-off. These two jump tests were performed without arm swing. A 3 min rest period was allowed between three trials of each test.

Straight Sprint test (S5-m , S10-m and S15-m). Acceleration speed was evaluated using a straight sprint test, involving sprinting S5m, S10m and S20-m as fast as possible from a stationary start position. Subjects were instructed to begin with their preferred foot forward, placed on a line marked on the floor from a standing position. The subjects performed three test trials. The recorded time for this test was the better of the two last trials.

Handball skill test. Speed, agility, and handball skills were tested by a slalom dribbling test. Subjects ran a distance of 15 m, back and forth, dribbling a handball around 5 cones. The distance between the starting line and the first cone, as well as between the other cones, was 3 m. Subjects ran individually (17). The better of 2 trials was recorded for statistical analysis. All tests were performed on an indoor synthetic pitch, and electronic timing gates (MicrogateRace time 2 Light Radio, Bolzano, Italy) were used to record times.

Statistical Analysis

Findings are reported as means ± standard deviations (SD). The reliability of jump tests (SJ and CMJ), running velocity and the handball skill test were assessed using intraclass correlation coefficients (ICC). Confidence limits (95%) for CV and ICC were calculated using Chi-square, and McGraw and Wong (1996) estimates, respectively. Pearson's product moment correlations and linear regression analyses were used to examine relationships between handball agility test performance and other measures of physical ability. Correlation coefficients were interpreted in accordance with the following scale of magnitudes as devised by Cohen (1988): $r< 0.1$, trivial; $0.1 \leq r < 0.3$, small; $0.3 \leq r< 0.5$, moderate; $r \geq 0.5$, large. Significance was assumed at 5% ($p\leq 0.05$). All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) (version 19.0 software for windows).

RESULTS

Reliability and data for all measures are presented in table 1 and 2. Significant correlations were found between HAT, 5-m and 10-m sprints ($r = 0.79$ and $r = 0.70$ respectively; $p<0.001$; Figure 1). The HAT was closely correlate with the handball specific skill test ($r = 0.74$; $p<0.01$; Figure 2), while only a moderate correlation between HAT and CMJ ($r= 0.42$; $p< 0.05$; Figure 3) was found.

Table 1. *Intraclass correlation coefficients for relative reliability and coefficient of variation of the measured parameters (n = 30).*

	ICC	95%IC	CV (%)
Handball agility test	0.94	0.92-0.96	3.1
Squat jump (cm)	0.97	0.91-0.97	4.2
Countermovement jump (cm)	0.96	0.95-0.98	3.4
Sprints 5-m (s)	0.95	0.90-0.97	4.2
Sprints 10-m (s)	0.92	0.86-0.91	4.3
Sprint 15-m (s)	0.91	0.90-94	4.1
Handball skill test (s)	0.95	0.91-0.97	4.2

ICC = intraclass correlation coefficient; CI = confidence interval; CV = coefficient of variation

Table 2. *Results of the measured parameters, values are given as mean ± SD, (n = 30).*

	Mean	± SD
New handball agility test (s)	7,62	0,84
Countermovement jump (cm)	35,14	7,32
Squat jump (cm)	33,52	6,45
Sprints 5-m (s)	1,22	0,15
Sprints 10-m (s)	2,07	0,23
Sprint 15-m (s)	2,90	0,24
Handball specific skill test (s)	8,29	1,01

Figure 1. *Relationships between the new handball agility test, Sprint 5-m and sprint 10-m*

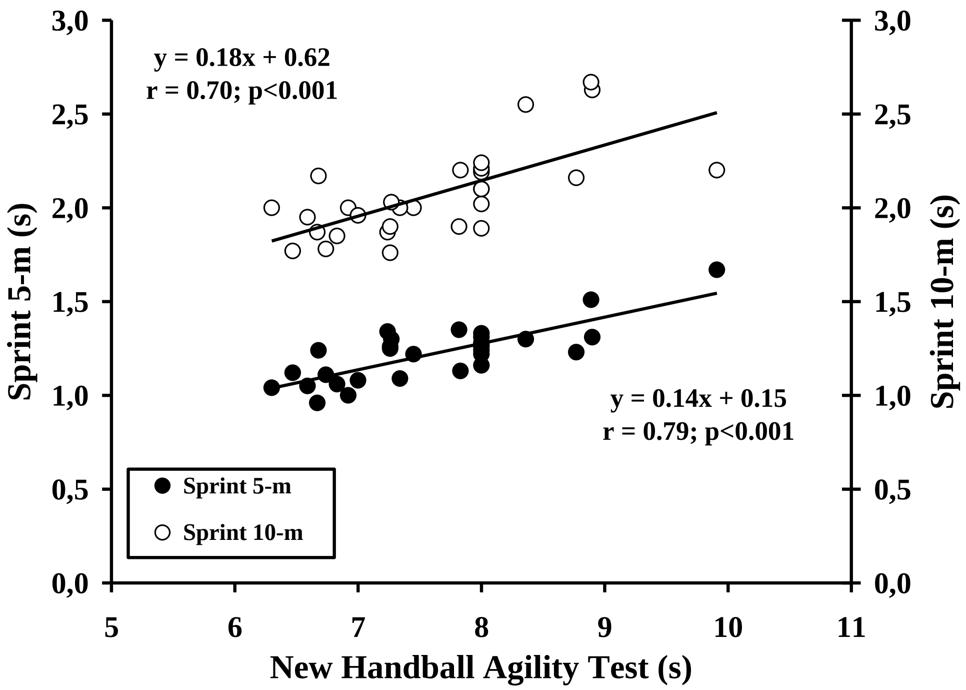


Figure 2. *Relationships between the new handball agility test and the handball skills test*

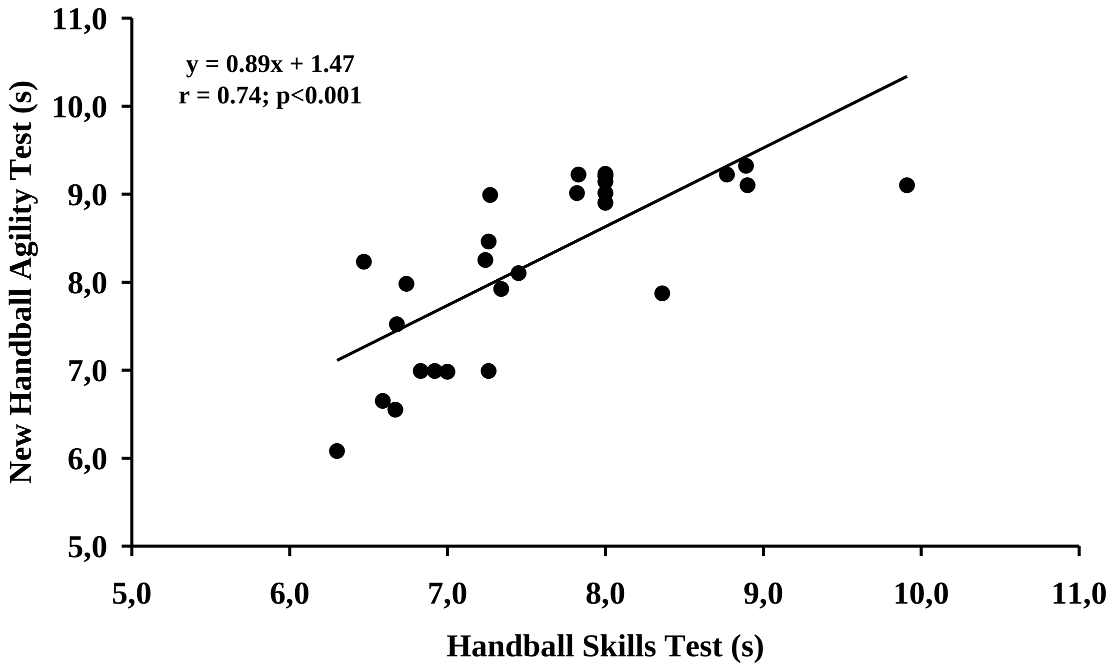
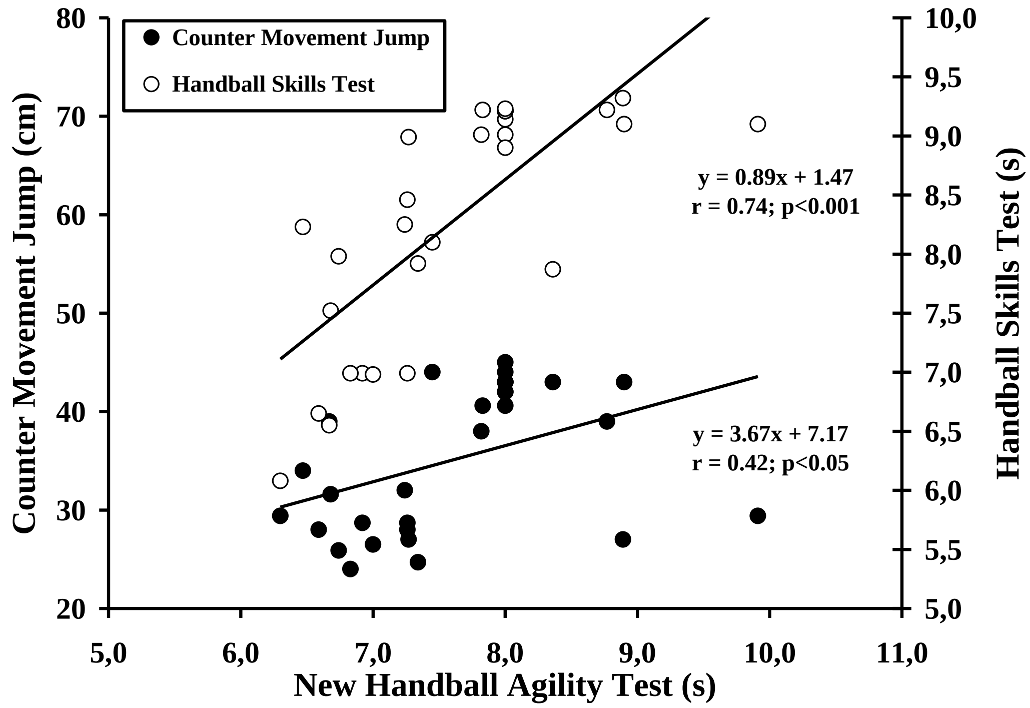


Figure 3. *Relationships between the new handball agility test, countermovement jump and squat jump*



DISCUSSION

In accordance with our hypothesis, the main finding from this study is that the performance scores of the HAT were reliable and significantly associated with several athletic qualities of lower limbs related to the youth handball players. To the authors' knowledge, this is the first study to report reliability of HAT for young handball players. The performances on the S5-m S10-m and S20-m test for acceleration and HAT test ($p < 0.001$). These data would initially suggest that acceleration, jumping, and agility share common physiological and biomechanical determinants in young handball players. The small range of data observed within the sample of 30 subjects in the earlier research reduced the possibility of observing high correlations between the tests.

The sprint velocity and acceleration over the first few seconds (i.e., less than 20 meters) of running are important for handball players, and the ability to accelerate over a single step could be a critical factor in some game situations (Hermassi et al. 2014). The relationship between the S5-m, S10-m, 15-m and HAT has not been investigated previously. But, the existence of significant relationships is at first inspection somewhat surprising, since the two tests were intended to measure apparently differing abilities (velocities and muscle explosive force). However, HAT test requires a sprint start with each change of direction, which could explain at least some of the observed relationship (Burgess et al. 2010).

Competitive handball requires frequent turning and changes of directions at a variety of intensities (Buchheit et al. 2009) and this demands both muscular power and strength. The vertical jump performance of handball players varies with their competitive level (Buchheit et al. 2009) showing that this field test provides a useful measure of their ability. Again, scores on this test are significantly correlated with the HAT. We found a significant correlation between the HAT and vertical jump performance. We expected that these two measures would be related because of the similarities in the muscle contraction pattern (stretch shortening cycle); many other results in the scientific literature show moderately close relationships between agility tests and jumping performance (Chaouachi et al. 2009).

The significant relationship between HAT and the handball skill test is likewise somewhat no surprising, since the items purportedly measured are Skill vs. agility and speed. As in the sprint test, the skill test is essentially based on sprinting forward or backwards, with the subject exerting explosive force at each change of direction. In the slalom dribbling skill test used in this study, the player is instructed to adopt only a single pattern of movement (dribbling back and forth) in order to cover the distance as rapidly as possible. One possible factor contributing to the positive correlation between the HAT test and dribble test could be the acceleration and deceleration of the legs and changes of direction during the turns in HAT test. Possibly, this demands similar abilities to the dribbling test.

The results suggest that the HAT is a better measure of handball-specific capability than an equivalent nonspecific field test. HAT is also a valid and reliable field based assessment that could be used for talent identification and young handball player's selections. However, further studies should be carried out using players of different age, sex and ability and across greater test-retest durations to confirm these findings. While performance in a HAT with changes of direction is significantly related to a range of other athletic qualities. Further research should aim to determine the extent to which other qualities, including the ability to tolerate metabolic stress, influence linear repeated sprint ability.

References

1. Karcher C and Buchheit M. On-court demands of elite handball, with special reference to playing positions. *Sports Med* 44: 797-814, 2014.
2. Young WB, James R, Montgomery I. Is muscle power related to running speed with changes of direction? *J Sports Med Phys Fitness;* 42:282–288, 2002
3. Sheppard JM, Young WB, Doyle TL, Sheppard TA, Newton RU.An evaluation of a new test of reactive agility and its relationship to sprint speed and change of direction speed. *J Sci Med Sport*; 9:342–349, 2006
4. Buchheit, M, Laursen, PB, Kuhnle, J, Ruch, D, Renaud, C, and Ahmaidi, S. Game-based training in young elite handball players. *Int J Sports Med;* 30: 251–258, 2009.
5. Chaouachi, A, Brughelli, M, Levin, G, Boudhina, NB, Cronin, J, and Chamari, K. Anthropometric, physiological and performance characteristics of elite team-handball players. *J Sports Sci;* 27: 151–157, 2009.
6. Visnapuu M, Jürimäe T. Relations of anthropometric parameters with scores on basic and specific motor tasks in young handball players. *Percept Mot Skills;* 108(3):670-6, 2009
7. Hermassi S, Gabbett TJ, Spencer M, Khalifa R, Chelly MS, Chamari K. Relationship between explosive performance measurements of the lower limb and repeated shuttle-sprint ability in elite adolescent handball players. *Int J Sports Sci Coaching;* V9: 5, 2014
8. Burgess DJ, Naughton GA. Talent development in adolescent team sports: a review. *Int J Sports Physiol Perform*, 5: 103-116, 2010

EFFECT OF IN-SEASON EXPLOSIVE STRENGTH TRAINING ON MAXIMAL LEG STRENGTH, JUMPING, SPRINTING, AND INTERMITTENT AEROBIC PERFORMANCE IN ELITE HANDBALL PLAYERS.

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ABSTRACT

Handball is a strenuous intermittent team sport with specific requirements for technical skills, tactical understanding, and physical performance(Karcher& Buchheit, 2014). The ability to produce explosive effort (i.e. sprinting, jumping, changing direction) is as important as aerobic capacity for success in handball players (Karcher & Buchheit, 2014). The purpose of this study was to examine the effect of a 10-week in-season combined strength with high-intensity training on physical performance in elite handball players during competition.

KEYWORDS: Handball, muscular strength, jumping performance, RSA test.

INTRODUCTION

Handball is characterized by high explosive actions performed at high velocities; therefore, success depends essentially upon well-developed muscular strength (Karcher & Buchheit, 2014). Even handballtraining is able to reproduce most of the patterns required for the conditioning of the players (Gorostiaga et al. 2006). Thus, it is necessary to use high intense and specific external loads(i.e., explosive strength) to benefit from considerable muscular adaptations, which is only possible with specific strength training sessions (Gorostiaga et al. 2006). Knowledge about strength training planning is decisive when increasing strength, endurance, coordination, explosive strength, speed and technical abilities (Crewther et al. 2005).

Understanding of the effects of specific strength training programs on body composition, vertical jump, muscular strength and repeated sprint performance can help coaches select the best training stimulus in order to improve the individual performance of their players. The majority of specific handball actions involve stretch shortening cycles, based on the fact that a concentric action produces higher peak torque when preceded by an eccentric contraction (Bobbert et al. 1996). As a result, strength training is essential to develop vertical jump capacity (Hermassi et al. 2001) and, consequently, to perform specific offensive (jump shots) and defensive (blocks) handball motor activities.Therefore, the aim of the present study was to of a 10-week in-season combined strength and high-intensity training on physical performance in elite handball players during competition.

METHODS

Participants

Twenty-two handball players (age: 18 .9 ± 0.4 years; body mass: 92.2 ± 10.3 kg; height: 1.91 ± 0.52 m; percentage body fat: 13.8 ± 2.3 %; handball experience: 9.1 ± 0.3 years) were randomly assigned to a control (*n*=10) or an experimental training group (*n*=12)were recruited from a single national-level team, under conditions approved by the Institutional Review Committee for the ethical use of human subjects, in accordance with current national and international laws and regulations. Subjects gave their written informed consent to participation in the study, after receiving both a verbal and a written explanation of the experimental design and its potential risks.

Testing Schedule

Players were familiarized with circuit training, lifting and 1-RM test procedures for two weeks before testing. A standardized battery of warm-up exercises was performed before maximal efforts. On the first test day, 1-RM of the half back-squat was determined. Day 2 was a rest day. On Day3, the repeated sprint test was performed, followed by the anthropometric assessment. Day 4 was also a rest day and on Day 5, squat and countermovement jumps and Yo-Yo intermittent recovery test (Yo-Yo IR1) were performed and recorded.

One Repetition maximum (1-RM) half back-squat

Each participant kept an upright position, looking forward and firmly grasping the bar with both hands with the bar supported on the shoulders. The player bent his knees until he reached the target of 90 degrees knee flexion. After reaching this position, the player raised himself to the upright position extending the lower limbs completely. Because this technique was unfamiliar for some of the participants, an instructor explained and demonstrated this lifting technique. All players performed eight technical training sessions during the month preceding the 1-RM measurements. During the familiarization session, a pretest 1-RM was performed to determine the approximate 1-RM value. To measure experimental 1-RM values, a barbell was loaded with free weights across the upper back of the participant using an initial loading corresponding to 90% of the pretest 1-RM. Two consecutive loaded half back-squats were performed. Each time a set of two repetitions were mastered, a load of 5 kg was added after allowing a recovery interval of about5 minutes. When the player performed two successful repetitions with his pretest 1-RM value, a load of 2.5 kg was added after the recovery period. If the participant was unable to successfully complete the second repetition with the new loading, the corresponding load was considered as the individual’s 1-RM. 1-RM was assessed in three to six attempts.

Repeated shuttle-sprint ability (RSA) test

Before the test, players completed a warm-up consisting of 10 min of jogging supplemented with an additional 3-5 single 15-m shuttle sprints with 2 min of passive recovery. No static stretching was allowed before the RSA protocol. An additional 3 min rest was given before players undertook the handball specific RSA test protocol. The RSA test consisted of six repetitions of 2 x 15-m maximal shuttle sprints with 180° turns (~6s), departing every 20s (Buchheit et al. 2010). During the ~15s recovery between sprints, subjects were required to perform an active recovery (brisk walking back to the starting line). Three seconds before starting each sprint, the subjects were asked to assume the start position and await the start signal. Two sets of timing gates (MicrogateSrl; Race time 2. Light Radio, Italy) were used, working in opposite directions, to allow subjects to start the next run from the same end at which they had finished the preceding sprint. Each sprint was initiated from an individually chosen standing position, 50 cm behind the timing gate, which started a digital timer. Strong verbal encouragement was provided to each subject during all sprints, and subjects were instructed to produce maximal effort for each sprint and to avoid pacing themselves. Three scores were calculated for each RSA test: Best sprint time in a single trial (RSA_{best});Total sprint time (RSA_{TT}); and Fatigue (RSA_{dec}). The RSA_{dec} was calculated using the percentage decrement method: 100 – (Total time / ideal time × 100); where the ideal time = 6 × RSA_{best} (Buchheit et al. 2010).

Squat (SJ) and countermovement jump (CMJ) tests

Squat jump (SJ) and countermovement jump (CMJ) variables (jump height, maximal force before take-off, maximal velocity before take-off and the average power of the jump) were determined using a force plate (Quattro Jump, version 1.04, Kistler Instrument AG, Winterthur, Switzerland). Jump height was determined as the center of mass displacement, calculated from the recorded force and body mass. For the SJ, subjects started at a knee angle of 90 degrees, were instructed to avoid any downward movement, and then performed a vertical jump by extending upwards, keeping their legs straight throughout the jump. The CMJ started from an upright position, making a rapid downward movement to a knee angle of ~90 degrees and simultaneously beginning to push-off. These two jump tests were performed without arm swing. A 3 min rest period was allowed between three trials of each test.

The Yo-Yo Intermittent Recovery Test Level 1

The Yo-Yo IR1 was performed according to the procedures outlined by Krustrup et al (2003). Briefly, the test consisted of 20-m shuttle runs performed at increasing velocity with 10 s of active recovery (consisting of 2 x 5 m of jogging) between runs until exhaustion. The end of the test was considered when the participant twice failed to reach the front line in time (objective evaluation) or he felt unable to complete another shuttle at the dictated speed (subjective evaluation). The total distance covered during the Yo-Yo IR1 was considered the test "score". Before the test, players performed a standardized warm up consisting of 5 min of low-intensity running followed by the first four bouts in the test. The reliability of the Yo-Yo IR1 test has been established resulting in a coefficient of variation (CV) of 3.6 % with an ICC of 0.94.

Training

The experimental training group performed a maximal leg strength program for 10 weeks besides their handball training sessions, while the control group only had their regular handball training sessions. Biweekly sessions were held on Tuesdays and Thursdays, immediately before normal handball training. 1-RM half-back squat exercise determined appropriate training loads. Each strength training session included a half-squat exercise to strengthen the lower limbs. Subjects trained at 80–90% of their personal 1-RM, performing 1–3 repetitions per set and 3–6 sets of each exercise, with 3- to 4-minute rest between sets

Statistical analyses

To compare the effects of the training protocols, a mixed design 2 (test occasion: pre-post: repeated measures) x 2 (group: control group, and resistance training group) analysis of variance (ANOVA) on each variable was used. The reliability as indicated by intra-class correlations (ICC) was 0.92 for 0. 97. The level of significance was set at $p \leq 0.05$. Statistical analysis was performed in SPSS version 18.0 (SPSS, Inc., Chicago, IL).

RESULTS

No significant differences between the groups in any of the variables were found at baseline. After 10 weeks, significant improvements in the 1RM half squats (p<0.0001; Table 1), SJ and CMJ (p<0.05; p<0.001 respectively; Table 2), Yo-Yo IR1 test (p<0.001), together with increased RSA_{best} (p<0.01), RSA_{TT} (p<0.001) and RSA_{dec} (p< 0.01) for the experimental training group were found compared with the control group.

Table 1: *Comparison of maximal strength of lower limb and vertical jump between heavy resistance group and control group before and after 10-weektraining.*

		EXG	CG
Maximal strength of lower limb (kg)	Pre	206,25 ± 12,45	205,01 ± 17,16
	Post	235,83 ± 9,49***	202 ± 13,17
Countermovement jump (cm)	Pre	43,75 ± 0,75	43,1 ± 0,74
	Post	47,00 ± 0,95**	43,4 ± 0,84
Squat jump (cm)	Pre	41,83 ± 1,19	40,7 ± 1,06
	Post	44,25 ± 0,75**	41,9 ± 0,88

***: p<0.001: **: p<0.01

Table 2: *Comparison of Yo-Yo Intermittent recovery testand RSA performance between heavy resistance group and control group before and after 10-weeksof training.*

		EXG	CG
Yo-Yo Intermittent recovery test ($km \cdot h^{-1}$)	Pre	17,01 ± 0,66	16,03 ± 0,78
	Post	18,23 ± 0,47***	16,60 ± 0,61
RSA best time (s)	Pre	6,7 ± 0,75	6,76 ± 0,33
	Post	6,2 ± 0,1**	6,60 ± 0,13
RSA Mean time (s)	Pre	6,9 ± 0,3	6,96 ± 0,33
	Post	6,5 ± 0,1**	6,80 ± 0,10
RSA total time (s)	Pre	40,5 ± 3,4	40,41 ± 3,73
	Post	39,1 ± 0,5***	41,01 ±1,38

***: p<0.001: **: p<0.01

DISCUSSION

The primary aims of this study were to determine whether elite male handball players could enhance muscle strength by an in-season program of strength training for the lower limbs, and whether gains could be realized without detriment to other aspects of performance. The answer to both of these questions is strongly positive; our results substantiate our hypothesis that strength training biweekly in season training enhances the maximal strength of lower limb, whether assessed by jumping or repeated sprinting. Moreover, there are concomitant gains of muscle volume and 1RM strength, and no evidence that the development of shuttle sprint has compromised the speed of the players.

However, competitive performance in handball depends not only on strength, but also on the ability to exert force at the speed required by this discipline. In the present study, longer contraction durations were associated with heavier loads; such a prescription seems best suited to maximizing strength (Kraemer et al. 2002). Many authors have replicated the finding of Gorostiaga et al. (1999) that whereas specific resistance training improves the strength of the leg extensors (12.2%; p < 0.01), no gains can be anticipated from low resistance forms of activity such as team handball practice. Gorostiaga et al. (2006) studied athletes with a greater initial training level (Schmidtbleicher, 1992).The application of heavy loading is fundamental to strength development, demanding maximal motor unit recruitment according to the “size principle”, with units also firing at higher frequencies (Behm, 1993). The development of large forces may also initiate force-feedback reflexes from the Golgi tendon organs and/or improve the synchronization of motor unit firing (Hakkinen, 1989).

Vertical jumping is frequent in both defensive (e.g., blocking, rebounding, and stealing) and offensive (e.g., passing, rebounding, and shooting) handball maneuvers (Hermassi et al. 2011). The classical vertical jump test differs somewhat from handball vertical jumping; nevertheless, this study showed gains in vertical jump height (12 and 14% for CMJ and SJ, respectively) similar to those seen during training of junior handball players (Hermassi et al. 2011) (7.5 and 10%

respectively). Christou et al. (2006) also found respective gains of 13.5 and 14.4% in the SJ and CMJ of soccer players over 8 weeks of strength training. Gorostiaga et al. (1999) are the only previous investigators to have studied the influence of resistance training on the jump performance of handball players. They reported significant increases in a group that had previously engaged only in team practice (6%; $p < 0.001$), but no changes of CMJ in either resistance training or control groups. This study used a high loading (80–90% of 1RM), which presumably led not only to muscle hypertrophy but also to neuronal adaptations, with an increase in the rate of force development (Schmidtbleicher, 1992).

Sprinting, acceleration, and repeated sprint performance are inherent to both practice and competition in handball. Such efforts depend not only on maximal strength, but also on power and agility. There is a velocity-specific effect, and for optimal performance, handball training should simulate the sport movements as closely as possible. Perhaps because of increases in muscle strength, our subjects showed increases rather than decreases in RSA_{best} ($p<0.01$), RSA_{TT} ($p<0.001$) and RSA_{dec} ($p< 0.01$) for the experimental training group compared with the control group in agreement with a recent study of junior soccer players (Kotzamanidis et al. 2005). This is the first study to demonstrate this point in handball players. Certainly, our data indicate that a combination of strength, handball technique, and competitive skills training significantly enhanced maximal and specific-explosive strength of the extremity over the 10-week program, and this should give players an advantage in repeated sprint ability (Buchheit et al. 2010).

The performance improvements shown in the present study are of great interest for handball coaches, because the performance of this sport relies greatly on the specific maximal strength, jump, and repeated sprint ability that were enhanced by the high resistance training regimen. Previous authors have found a similar need for deliberate strength training in other sports, but this is demonstrated here for the first time in elite handball players. It is recommended that handball coaches implement in season strength training to enhance the performance of their players. Potential neuromuscular explanations of the observed gains merit further investigation.

References

1. Behm, DG. Neuromuscular implications and applications of resistance training. *J Strength Cond Res*, 1995; 9: 264–274.
2. Bobbert, MF, Gerritsen, KG, Litjen, MC, and Van Soest, AJ.Why is countermovement jump height greater than squat jump height?*Med Sci Sports Exerc*,1996; 28:1402-1412.
3. Buchheit M, Mendez-Villanueva A, Quod M, Quesnel T, and Ahmaidi, S. Improving acceleration and repeated sprint ability in well-trained adolescent handball players: speed versus sprint interval training. *Int J Sports Physiol Perform*, 2010; 5: 152-164.
4. Christou, M, Smilios, I, Sotiropoulos, K, Volaklis, K, Pilianidis, T, and Tokmakidis, SP. Effects of resistance training on the physical capacities of adolescent soccer players. J Strength Cond Res, 2006; 20: 783–791.
5. Crewther, B, Cronin, J, and Keogh, J. Possible stimuli for strength and power adaptation: Acute mechanical responses. *Sports Med*, 2005; 35: 967–989.
6. Gorostiaga, EM, Granados, C, Ibanez, J, Gonza´ lez-Badillo, JJ, andIzquierdo, M. Effects of an entire season on physical fitness changesin elite male handball players. *Med Sci Sports Exerc*, 2006; 38: 357–366.
7. Gorostiaga, EM, Izquierdo, M, Iturralde, P, Ruesta, M, and Ibanez, J. Effects of heavy resistance training on maximal and explosive force production, endurance and serum hormones in adolescent handball players. *Eur J Appl Physiol Occup Physiol*, 1999; 80: 485–493.
8. Hakkinen, K. Neuromuscular and hormonal adaptations during strength and power training. A review. *J Sports Med Phys Fitness*, 1989; 29: 9–26.
9. Hermassi S, Chelly MS, Tabka Z, Shephard RJ, Chamari K. Effects of 8-week in-season upper and lower limb heavy resistance training on the peak power, throwing velocity, and sprint performance of elite male handball players.*J Strength Cond Res*, 2011; 25(9):2424-33.
10. Karcher C and Buchheit M. On-court demands of elite handball, with special reference to playing positions. *Sports Med*, 2014; 44: 797-814.
11. Kotzamanidis, C, Chatzopoulos, D, Michailidis, C, Papaiakovou, G, and Patikas, D. The effect of a combined high-intensity strength and speed training program on the running and jumping ability of soccer players. J Strength Cond Res 19: 369–375, 2005.
12. Kraemer, WJ, Adams, K, Cafarelli, E, Dudley, GA, Dooly, C, Feigenbaum, MS, Fleck, SJ, Franklin, B, Fry, AC, Hoffman, JR, Newton, RU, Potteiger, J, Stone, MH, Ratamess, NA, and Triplett-McBride, T. Progression models in resistance training for healthy adults. *Med Sci SportsExerc*, 2002; 34: 364–380,
13. Krustrup P, Mohr M, Amstrup T, Rysgaard T, Johansen J, Steensberg A, Pedersen PK, and Bangsbo J. The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Med Sci Sports Exerc*, 2003; 35: 697-705.
14. Marques, MC and Gonza´ lez-Badillo, JJ. In-season resistance training and detraining in professional team handball players. *J Strength Cond Res*, 2006; 20: 563–571.
15. Schmidtbleicher, D. Training for power events. In: Strength and Power in Sport. Komi, PV, ed. London, United Kingdom: Blackwell, 1992. pp. 381–395.

UNUSUAL TIBIAL PLATEAU FRACTURE IN RELATION WITH KNEE BRACE IN HANDBALL: A CASE STUDY

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SUMMARY

We report a case of a 47-year-old male handball player suffering a direct trauma in competition of his right lateral knee against the hinges of a braced defender. We believe that the hinged brace might have caused or at least aggravated the injury suffered by the patient and that the rules of handball should be more detailed on the topic of protective gear.

KEYWORDS: Tibial fracture, handball, knee brace

INTRODUCTION

Handball evolved into one of the most physically demanding contact sports and players are getting bigger, stronger and faster. The primary and secondary prevention of injuries, as well as the return to sports after injury, are gaining in importance. Manufacturers of orthopaedic orthoses offer numerous solutions to prevent and to treat all kinds of injuries. The goal is to facilitate the rehabilitation and to get patients back to their previous level of performance. For knee injuries, different types of braces exist, varying in material and given support, from neoprene sleeves, to hinged knee braces and full carbon functional knee brace. Their main purpose is to give stability to protect the knee from direct trauma or distortions, which could affect the soft tissues, such as cruciate ligaments or menisci. Looking at the different company brochures, people are depicted performing various sports using different types of braces. Even professional athletes are shown using and advertising protective knee braces[22]. In the highest German Handball League, but also in international competitions, some athletes rely on hinged knee braces during games, especially as secondary prevention after ligament injuries or operations (Fig. 1). As those athletes are role models for the younger generations, the use of braces is likely to increase.


Fig: 1: Germany vs. Austria

But according to the official handball rules of the international handball federation[20], any object that could be dangerous to players is not permitted. It is not explicitly mentioned, but this should normally include protective gear with hard metal parts. Other contact sports such as football[18] and volleyball[19] have similar rulings regarding player equipment. In basketball[16], protective gear is mentioned, but their rulebook is not specific and the rule could be bent in either favour or against the use of such braces. Only the official rulebook of American football[21] has detailed guidelines on the use of protective braces with metal or hard plastic parts. They are only allowed when they are properly covered on all edges and surfaces by a minimum of 3/8 inch (approx. 1cm) foam rubber or similar soft material. In handball, the final decision on whether braces are allowed or not, ultimately lies in the hand of the referees. The danger of hard plastic or metal parts in braces is often underrated, because the purpose of those braces is to prevent injuries. Injuries involving protective knee braces are rare since their use is still limited, but a direct trauma to those hard plastic parts can cause serious injuries as we will try to show you below.

CASE REPORT

A 47-yo male former professional handball player presented himself at our emergency unit after he was injured during an official handball game. While he was about to jump off his left foot to shoot, he hit his right lateral knee, which was in a slightly bend position, against the opponent´s hinges of his knee brace (Fig. 2) which were covered by hard plastic. In our patient's history, we found an old distension of the anterior cruciate ligament and retro patellar arthrosis with already some degenerative meniscus damage.

Fig. 2 : ©McDavid PS II

Fig. 3: CT-Scan and X-Ray

The clinical examination showed a non-weight bearing patient using crutches, a significant, visible and palpable effusion of the right knee. The patient's range of motion was reduced with a maximum flexion of 80° with a tenderness on the lateral tibial plateau. Radiographic imaging consisted of x-ray and CT-scan to evaluate the bony structures, as well as an MRI to assess the soft tissue damage. The x-rays show a longitudinal fracture of the lateral tibial plateau and the CT-scan revealed a 6mm deep impaction of the articular surface on the lateral tibial plateau (Fig. 3). The MRI images reveal an abundant effusion, a bone bruise of the lateral tibia, a sprain of the anterior cruciate ligament, a bony avulsion of the posterior cruciate ligament, the fracture line and a lateral collateral ligament lesion.

The final diagnosis was a fracture of the lateral tibial head with impactation (AO41C2), a subtotal bony avulsion of posterior cruciate ligament and an elongation of the lateral collateral ligament and the anterior cruciate ligament (ACL). The therapy consisted of an arthroscopy, with releveling of the tibial articular surface, and an open reduction with internal fixation of the longitudinal fracture using metal plates and screws (Fig. 4). The postoperative care included medical and physical pain relief, 6 weeks of non-weight bearing with a straight knee brace while doing physiotherapy to regain force and full passive and active range of motion, followed by 6 weeks of partial weight bearing without knee brace. Thromboprophylaxis was performed with intracutaneous injections of low weight heparin and physical measures, such as compression socks, ice and elevation until partial weight bearing after 6 weeks. Follow up controls after 12 and 18 weeks showed a good range of motion, a sufficient stability of the posterior cruciate ligament and a lack of muscle strength. Radiographic controls showed a good fracture healing. Cycling, closed-chain strengthening exercises and physiotherapy with isokinetic training were performed to reinforce the lower limb. The patient was able to run after 6 months and a return to sports was possible 9 months after surgery.

Fig. 4: X-Ray after surgery

DISCUSSION

An important question when using braces is whether or not these braces have an effect on performance. A previously feared negative effect on performance did not show in the studies using the newer brace models. Many studies on healthy subjects compared the effects on proprioception, coordination, balance and strength while using neoprene sleeves to the same performance when using hinged braces. Baltaci et al.[2] suggest that Prophylactic knee braces can be used for both healthy subjects and athletes to enhance proprioception, coordination, maximal force, and balance.

Other studies could not confirm the result. They showed that the protective knee brace and neoprene knee sleeves do not influence neither positively nor negatively the knee performance of uninjured active subjects[4,11]. In addition, no differences in performance were observed when using neoprene sleeves or not. On ACL-reconstructed subjects, functional knee braces do not produce superior outcomes when compared with neoprene sleeves. Current evidence does not support the recommendation to use an ACL functional knee brace after ACL reconstruction[3].

There are not many clinical studies studying the effect of functional knee braces on injury prevention. Most studies were performed on American football players in college. It is considerable that not all players have a high risk of MCL injury. The type of session (games, practices), the position group (linemen, linebackers/tight ends, skill), and the string (players, nonplayers) to which the athlete is assigned have more impact on the occurrence of an medial collateral ligament (MCL) injury than does the knee brace[12].

Although a final conclusion cannot be drawn, at this point in time, it appears that braces may be effective in reducing the risk of incurring an MCL sprain in football[1]. The findings of most of the biomechanical studies[5,6,7,8,13] performed in the laboratory setting suggest an efficacy of protective knee braces in preventing MCL injuries that occur from a valgus impact. They showed, using surrogate knee models, that, although some braces appear better than others, currently available off-the-shelf braces can generally provide 20% to 30% greater MCL resistance to a lateral blow at low velocity. Knee braces with sufficient stiffness appear to be more effective in distributing the force of a valgus blow away from the knee to the thigh and tibia[8].

The effect of knee bracing on the prevention of ACL injuries, which occur from external blows to the knee, remains unclear. A possible reduction in ACL injuries is suggested, but not proven, while the biomechanical studies show conflicting results[7,8,13]. Surrogate knee model studies of valgus blows to the straight or slightly flexed knee, show evidence that the ACL is given even greater protection at slow speeds and low impact forces than is the MCL, while other laboratory-based in vivo studies indicate no brace effectiveness in protecting the ACL.

However, bracing limited the excessive tibial rotation after ACL-reconstruction during pivoting that occurs in high-risk sports. Full restoration to normative values was not achieved. Thereby, braces may have the potential to decrease rotational knee instability that still remains after ACL reconstruction[9].

A review from Salata et. al.[15] evaluating the effectiveness of prophylactic knee bracing showed no medical evidence to support routine use of bracing in high school football. For college football, effectiveness in high-risk positions is suggested. No recommendation could be given in favour or at the expense of hinged knee braces for injury prevention in collegiate football. Unfortunately there are no studies available for other sports[10,14].

CONCLUSION

There is a risk of injury with the use of functional knee braces, even if it is small. Hinged neoprene braces do not look dangerous, and the prevention aspect can be misleading. A positive effect of knee braces on injury prevention is plausible, but further studies, also looking at other sports than American football, are needed to really clarify the effect of protective knee braces on injury prevention.Still we think that more restrictive and detailed rules are needed, to facilitate decision-taking by the referees and subsequently to protect our athletes from injury.

References:

1. Albright JP, Powell JW, Smith W, et al. Medial collateral ligament knee sprains in college football: effectiveness of preventive braces. Am J Sports Med. 1994; 22:12-18.
2. Baltaci G, Aktas G, Camci E, Oksuz S, Yildiz S, Kalaycioglu T (2011). The effect of prophylactic knee bracing on performance: balance, proprioception, coordination, and muscular power. Knee Surgery, Sports Traumatology, Arthroscopy: doi: 10.1007/s00167-011-1491-3
3. Birmingham TB, Bryant DM, Giffin JR, Litchfield RB, Kramer JF, Donner A, Fowler PJ (2008). A randomized controlled trial comparing the effectiveness of functional knee brace and neoprene sleeve use after anterior cruciate ligament reconstruction: Am J Sports Med April 2008 36 648-655.
4. Bottoni G, Herten A, Kofler P, Hasler M, Nachbauer W (2013). The effect of knee brace and knee sleeve on the proprioception of the knee in young non-professional healthy sportsmen. Knee, 20 (6), pp. 490-492: doi:10.1016/j.knee.2013.05.001
5. Brown TD, Van Hoeck JE, Brand RA. Laboratory evaluation of prophylactic knee brace performance under dynamic valgus loading using a surrogate leg model. Clin Sports Med. 1990;9:751-762
6. Daley BJ, Ralston JL, Brown TD, Brand RA. A parametric design evaluation of lateral prophylactic knee braces. J Biomech Eng. 1993;115:131-136.
7. Erickson AR, Yasuda K, Beynnon B, Johnson R, Pope M. An in vitro dynamic evaluation of prophylactic knee braces during lateral impact loading. Am J Sports Med. 1993;21:26-35.
8. France EP, Paulos LE, Jayaraman G, Rosenberg TD. The biomechanics of lateral knee bracing, part II : impact response of the braced knee. Am J Sports Med. 1987;15:430-438
9. Giotis D, Zampeli F, Pappas E, Mitsionis G, Papadopoulos P, Georgoulis AD (2013). Effects of knee bracing on tibial rotation during high loading activities in anterior cruciate ligament-reconstructed knees. Arthroscopy. 2013 Oct;29(10):1644-52.
10. Masini BD1, Owens BD (2013). Current recommendations for anterior cruciate ligament bracing: when to use. Phys Sportsmed. 2013 Feb;41(1):35-9. doi: 10.3810/psm.2013.02.1997.
11. Mortaza N, Ebrahimi I, Jamshidi AA, Abdollah V, Kamali M, et al. (2012) The Effects of a Prophylactic Knee Brace and Two Neoprene Knee Sleeves on the Performance of Healthy Athletes: A Crossover Randomized Controlled Trial. PLoS ONE 7:doi:10.1371/journal.pone.0050110
12. Najibi S, Albright JP (2005). The Use of Knee Braces, Part: Prophylactic Knee Braces in Contact Sports. Am J Sports Med: 2005 Apr;33(4):602-11
13. Paulos LE, Cawley PW, France EP. Impact biomechanics of lateral knee bracing : the anterior cruciate ligament. AM J Sports Med. 1991;19:337-342
14. Pietrosimone BG, Grindstaff TL, Linens SW, Uczekaj E, Hertel J (2008). A systematic review of prophylactic braces in the prevention of knee ligament injuries in collegiate football players. J Athl Train: 2008 Jul-Aug; 43(4): 409–415. doi: 10.4085/1062-6050-43.4.409
15. Salata MJ, Gibbs AE, Sekiya JK (2010). The effectiveness of prophylactic knee bracing in american football: a systematic review. Sports Health: A Multidisciplinary Approach September/October 2010 vol. 2 no. 5 375-379: doi: 10.1177/1941738110378986
16. http://www.fiba.com/downloads/Rules/2014/Official_Basketball_Rules_2014_Y.pdf
2014 Official Basketball Rules. (07/09/14)
17. http://www.irblaws.com/downloads/IRB_Laws_2014_EN.pdf Rugby Union Laws of the Game 2014. (07/09/14)
18. http://www.fifa.com/mm/document/footballdevelopment/refereeing/02/36/01/11/27_06_2014_new--lawsofthegameweben_neutral.pdf FIFA Laws of the Game 2014/2015. (07/09/14)
19. http://www.fivb.org/EN/Refereeing-Rules/documents/FIVB-Volleyball_Rules2013-EN_V08_20130516.pdf
Official Volleyball Rules 2013-2016. (07/09/14)
20. http://www.ihf.info/files/Uploads/NewsAttachments/0_RuleGame_GB.pdf
International Handball Federation Rules of the Game. (07/09/14)
21. http://static.nfl.com/static/content/public/image/rulebook/pdfs/2013%20-%20Rule%20Book.pdf
2013 Official playing rules of the national football league. (07/09/14)
22. http://www.bauerfeind.com/de/produkte/bandagen/knie-huefte-oberschenkel/softec-genu.html (02.12.2015)

CLARIFICATION OF ATTACKING ASPECTS IN OFFENSE SET-PLAY USING SEQUENCE ANALYSIS IN HANDBALL

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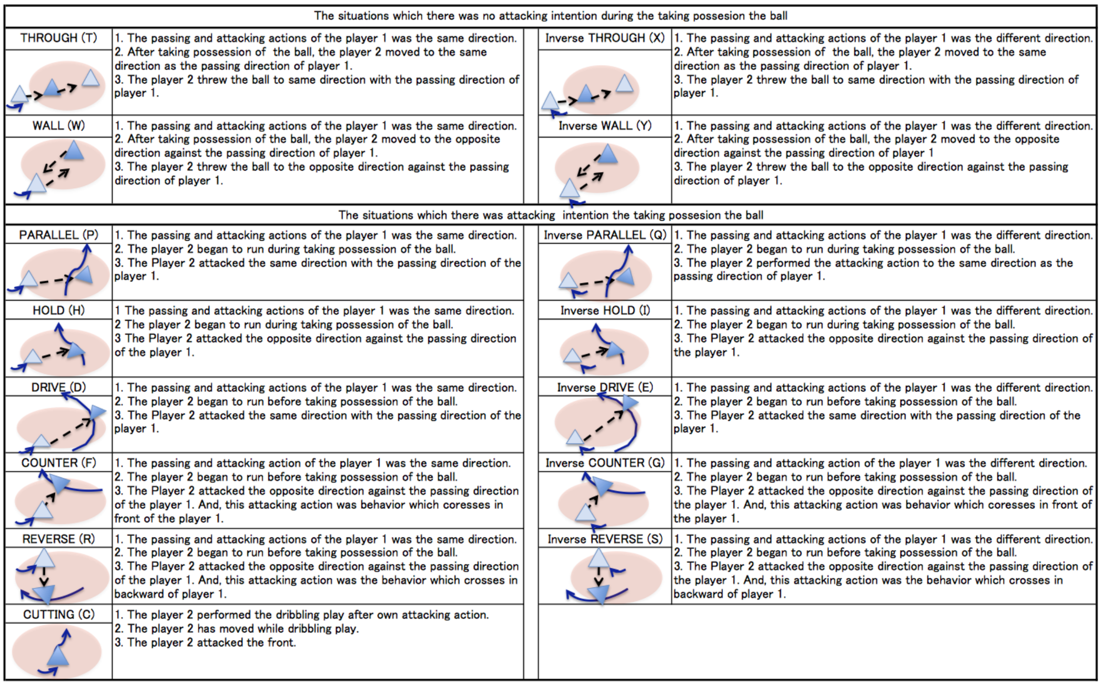
Summary

The purpose of this study was to clarify the structure of continuous attack play from the viewpoints of the clarification of tactical behavior and the prevention of injury. We recorded the single attacking action from the opening of attacking action to finishing in chronological order. The attacking play actions during the offense set-play were classified into 15 kinds of attacking action. We found that the structures of attacking behavior were different among the attacking phases during offence set-play. The clarification of structures of attacking behavior was helpful in improving the tactical behavior and in preventing injury.

Key notational analysis, sequence analysis, offense set-play

Introduction

Notational analysis quantifies for tactical actions as "When", "Where", "Who", "What" and "How" and can be used for evaluation of game performance. In handball, the number of scored goals[1, 2] and the distribution of successful shooting play spaces[3,4,5] have been studied. In general, a notational analysis can assess the total tactical behavior and the important aspects of the game to evaluate single actions. In order to gain deeper insight into the tactical behavior of the individual and team, it is necessary to record the multiple tactical actions and to analyze the sequence of continuous attacking actions in chronological order. Also, we determined what kind of sequence of continuous attacking actions is causing injury during handball game.



The situations which there was no attacking intention during the taking possesion the ball			
THROUGH (T)	1. The passing and attacking actions of the player 1 was the same direction. 2. After taking possession of the ball, the player 2 moved to the same direction as the passing direction of player 1. 3. The player 2 threw the ball to same direction with the passing direction of player 1.	Inverse THROUGH (X)	1. The passing and attacking actions of the player 1 was the different direction. 2. After taking possession of the ball, the player 2 moved to the same direction as the passing direction of player 1. 3. The player 2 threw the ball to same direction with the passing direction of player 1.
WALL (W)	1. The passing and attacking actions of the player 1 was the same direction. 2. After taking possession of the ball, the player 2 moved to the opposite direction against the passing direction of player 1. 3. The player 2 threw the ball to the opposite direction against the passing direction of player 1.	Inverse WALL (Y)	1. The passing and attacking actions of the player 1 was the different direction. 2. After taking possession of the ball, the player 2 moved to the opposite direction against the passing direction of player 1 3. The player 2 threw the ball to the opposite direction against the passing direction of player 1.
The situations which there was attacking intention the taking possesion the ball			
PARALLEL (P)	1. The passing and attacking actions of the player 1 was the same direction. 2. The player 2 began to run during taking possession of the ball. 3. The Player 2 attacked the same direction with the passing direction of the player 1.	Inverse PARALLEL (Q)	1. The passing and attacking actions of the player 1 was the different direction. 2. The player 2 began to run during taking possession of the ball. 3. The player 2 performed the attacking action to the same direction as the passing direction of player 1.
HOLD (H)	1 The passing and attacking actions of the player 1 was the same direction. 2 The player 2 began to run during taking possession of the ball. 3 The Player 2 attacked the opposite direction against the passing direction of the player 1.	Inverse HOLD (I)	1. The passing and attacking actions of the player 1 was the different direction. 2. The player 2 began to run during taking possession of the ball. 3. The Player 2 attacked the opposite direction against the passing direction of the player 1.
DRIVE (D)	1. The passing and attacking actions of the player 1 was the same direction. 2. The player 2 began to run before taking possession of the ball. 3. The Player 2 attacked the same direction with the passing direction of the player 1.	Inverse DRIVE (E)	1. The passing and attacking actions of the player 1 was the different direction. 2. The player 2 began to run before taking possession of the ball. 3. The Player 2 attacked the same direction with the passing direction of the player 1.
COUNTER (F)	1. The passing and attacking action of the player 1 was the same direction. 2. The player 2 began to run before taking possession of the ball. 3. The Player 2 attacked the opposite direction against the passing direction of the player 1. And, this attacking action was behavior which coresses in front of the player 1.	Inverse COUNTER (G)	1. The passing and attacking action of the player 1 was the different direction. 2. The player 2 began to run before taking possession of the ball. 3. The Player 2 attacked the opposite direction against the passing direction of the player 1. And, this attacking action was behavior which coresses in front of the player 1.
REVERSE (R)	1. The passing and attacking actions of the player 1 was the same direction. 2. The player 2 began to run before taking possession of the ball. 3. The Player 2 attacked the opposite direction against the passing direction of the player 1. And, this attacking action was the behavior which crosses in backward of player 1.	Inverse REVERSE (S)	1. The passing and attacking actions of the player 1 was the different direction. 2. The player 2 began to run before taking possession of the ball. 3. The Player 2 attacked the opposite direction against the passing direction of the player 1. And, this attacking action was the behavior which crosses in backward of player 1.
CUTTING (C)	1. The player 2 performed the dribbling play after own attacking action. 2. The player 2 has moved while dribbling play. 3. The player 2 attacked the front.		

Figure 1 Expalanation of criteria to classify the attacking play actions.
The attacking play actions during the offense set-play were classified into the 15 kinds of attacking play action.
1. The direction of passing the ball and the direction of attacking action of the player 1, as providing the ball for the player 2. 2. The timing which begins to move during the receiving the ball of the player 2
3. The direction of attacking action of the player 2 after taking possession of the ball.

Carling et al.[6] suggested analyzing action sequences, i.e. chains of sequential single action. There are also studied the relationship between sequences of actions during beach volleyball[7] and handball[8,9]. In our previous study[10], we demonstrated that an attacking action of a player could be classified into 12 kinds of attacking play action during offense set-play in handball. We have succeeded in representing the attacking behavior as a sequence code by indicating the continuous attacking actions in chronological order. In this study, the sequence of continuous attacking actions in the offense set-play could be easily observed. Thus, in this study, we clarified the structure of the continuous attacking play from the viewpoints of tactical behavior and prevention of injury, as a pilot study.

Methods

We analyzed the offense set-plays of 42 games in the 2012 European Women's Handball Championship in Serbia. In total, 21,381 single actions were recorded. The offense set-plays were 4,310 times. The attacking play actions during the offense set-play were classified into the 15 kinds (figure 1).

The classifying criteria of attacking play action were as follows:

1. The direction of passing the ball and the direction of attacking action of the player 1, as providing the ball for the player 2
2. The timing which begins to move during the receiving the ball of the player 2
3. The direction of attacking action of the player 2 after taking possession of the ball, against the passing direction of the player 1

We recorded the single attacking action from the opening of the attacking action to finishing in chronological order. The definitions of finishing the attacking actions were foul by the opposite team, technical miss and foul by own team, and shooting play.

In this study, we classified the three attacking phases during the offense set-play to compare the differences of attacking phases. The classified attacking phases were "opening", "break and continuing" and "finishing". The "opening" phase was including the first play during the attacking phase. The "finishing" phase was including the terminating play during the attacking phase. The "break and continuing" was excluding the first play and the terminating play during the attacking phase. In "finishing" phase, the four continuous attacking actions were retraced from the terminating play.

The rate of attacking action was expressed as a relative value. Pearson's chi-square test was used to assess the differences among each attacking phase as "opening", "break and continuing" and "finishing" phases, complemented adjusted residual analysis.

Results &Discussion

We observed that the number of single attacking actions were 21,381 times in this study. The distributions of 15 kinds of attacking actions were 34.4% in "THROUGH" (T), 16.8% in "WALL" (W), 0.1% in "inverse THROUGH" (X), 0.1% in "inverse WALL" (Y), 11.3% in "PARALLEL" (P), 12.3% in "HOLD" (H), 10.2% in "COUNTER" (F), 9.4% in “REVERSE (R)”, 3.0% in "DRIVE" (D), 0.6% in “CUTTING" (C), 0.3% in "inverse PARALLEL" (Q), 1.2% in "inverse HOLD" (I), and 0.4% in "inverse COUNTER" (G), respectively.

The number of two continuous attacking actions, three attacking actions and four continuous attacking actions were decreased to 79.4%, 60.0% and 43.1% from the number of single attacking actions. The decrease frequency of attacking actions in which were involved in the increased attacking sequence were different among the kinds of attacking action. The sequence of attacking action starting from "T" and "W" were decreased to 98.2% and 97.8% in two continuous attacking actions and to 84.0% and 80.9% in three continuous attacking actions and to 65.8% and 59.9% in four continuous attacking actions, respectively. In "P", "H", "F" and "R", the decrease of that were 58.3%, 65.9%, 56.7% and 74.6% in two continuous attacking actions, and 31.4%, 38.7%, 36.7% and 48.4% in three continuous attacking actions, and 18.9%, 22.5%, 21.7% and 31.5% in four continuous attacking actions, respectively. In addition, the decrease frequency of the sequence of attacking actions starting from "D", "C", "I" and "G" were 30.5%, 46.6%, 20.5%, 34.1% in two continuous attacking actions, and 15.2%, 29.8% in three continuous attacking actions in "D", "C", and 8.6% in four continuous attacking actions in "D". These decreased frequency were larger than that of "P", "H", "F" and "R".

The diversity of attacking actions involved in the increased attacking sequence was different among the kinds of attacking action. The sequence of continuous attacking actions starting from "T" and "W" were increased along with the increasing of continuous attacking actions. The numbers of "T" and "W" were seven and 11 kinds in two continuous attack actions, 49 and 24 kinds in three continuous attack actions, and 166 and 95 kinds in four continuous attack actions, respectively. The diversities of "T" and "W" were higher than those in "P" (11 kinds in two, 24 kinds in three, 24 kinds in four), "H" (11 kinds in two, 32 kinds in three, 33 kinds in four), "F" (10 kinds in two, 30 kinds in three, 25 kinds in four) and "R" (13 kinds in two, 38 kinds in three, 39 kinds in four). And, the diversities of "D" (6 kinds in two, 3 kinds in three), "C" (3 kinds in two, 1 kind in three), "I" (1 kind in two) and "G" (1 kind in two) were small. In addition, the sequence of continuous attacking actions starting from "Q", "G" and "S" were not continued to two, three and four continuous attacking actions. From these results, we found that the continuity of attacking action with increasing continuous attacking actions was different from a kind of single attacking action used.

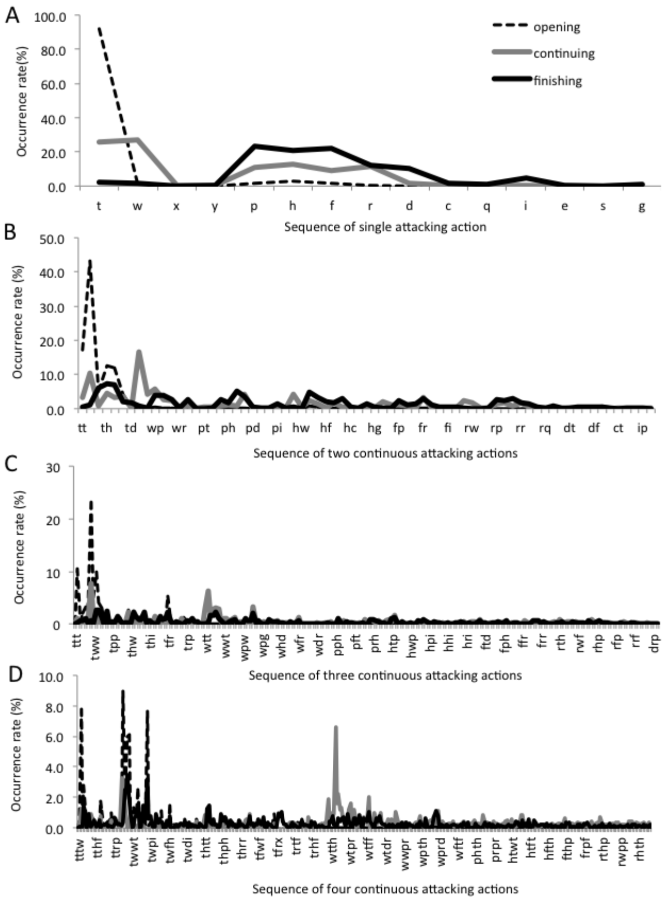


Figure 2 Occurrence rate during the sequence of continuous attacking actions
A: the single attacking action, B: the sequence of two continuous attacking actions, C: the sequence of three continuous attacking actions, D: the sequence of four continuous attacking actions.

Figure 2 demonstrated the occurrence rate of the attacking actions sequence during "opening", "break and continuing" and "finishing" phases. These results indicated that there were specific attacking actions in each attacking phase.

In the "opening" phase, the occurrence rate of "T" was higher than that of others during starting attacking behavior. "T" and "W" were selected during the secondary attacking actions and the occurrence rate of "T"-"T" and "T"-"W" was higher in the two continuous attacking actions. In three continuous attacking actions, "T"-"T"-"F", "T"-"T"-"H", "T"-"T"-"R", "T"-"T"-"W", "T"-"W"-"P", "T"-"W"-"R", "T"-"W"-"T" and "T"-"W"-"W" were selected. Following, the occurrence frequency in four continuous attacking actions were used the "T"-"T"-"F"-"T", "T"-"T"-"F"-"W", "T"-"T"-"W"-"T", "T"-"W"-"T"-"R" and "T"-"W"-"T"-"W". These results demonstrated that "T" and "W" were heavily used in the "opening" phase. Thus, it is thought that the high occurrence rate of "T" and "W" during the "opening" phase was preparing action in order to make a favorable numerical or positional advantage.

In the "break and continuing" phase, high occurrence rate was "W", "X", "Y" and "R" during the first attacking actions. The "R"-"T", "R"-"W", "R"-"X", "W"-"T", "W"-"W" and "W"-"R" were more selected in the two continuous attacking actions. Interestingly, the occurrence rate of the two continuous attacking actions also was high in "F"-"T", "F"-"W", "G"-"T", "H"-"T", "H"-"W", "P"-"T" and "P"-"W" in despite a lack of "H", "P", "F" and "G" during the first attacking actions. In three continuous attacking actions, "T", "W", "H", "F" and "R" were added to the sequence code of two continuous attacking actions. Similarly, "T", "W" and "H" were added to the sequence code of three continuous attacking actions during four continuous attacking actions. These results indicated that the use of "H", "P" and "F" and not only "T" and "W" were important in making a favorable numerical or positional advantages and in breaking the balance of the defender during the "break and continuing" phase.

In the "finishing" phase, we retraced the four continuous attacking actions from the terminating play. The occurrence rates of "C", "D", "F", "G", "I", "P", "Q" and "R" in terminating attacking action during the "finishing" phase were observed more frequently. These observed attacking actions during the "finishing" phase were different to the results of "opening" and "break and continuing" phases. In addition, these single attacking actions such as "C", "D", "F", "G", "I", "P", "Q" and "R" were not in continued with increasing continuous attacking actions during "opening" and "break and continuing" phases. Thus, attacking actions such as "C", "D", "F", "G", "I", "P" and "Q" might be performed in order to get the goal during terminating attacking play. In the two continuous attacking actions, "T", "W", "P", "H", "C", "D", "F", "R" and "Q" were used prior to terminating attacking play. And, in the three continuous attacking actions during the "finishing" phase, the "F"-"T"-"D", "H"-"H"-"I", "H"-"P"-"I", "H"-"T"-"D", "P"-"P"-"F", "P"-"R"-"I", "R"-"P"-"F", "W"-"H"-"I", "W"-"P"-"F", "W"-"P"-"I" were observed. In comparison to between the results of "finishing" and "opening" phases and to between that of "finishing" and "break and continuing" phases, the occurrence rate of attacking actions such as "C", "D", "F", "G", "I", "P", "Q" and "R" were higher in "finishing" phase. Therefore, it is thought that the sequence of continuous attacking actions using combination of "C", "D", "F", "G", "I", "P", "Q" and "R" were used to get a goal during "finishing" phase.

Conclusion

We found that the structures of attacking behavior were different among the attacking phases during offence set-play. In the “opening” phase, the sequence of attacking action was made by the combination of “T” and “W” single attacking actions. In the "break and continuing" phases, the sequence of attacking action was made by the combination of "H", "P" and "F" in addition to “T” and “W”. In the "finishing" phase, the sequence of attacking action was made by the combination of "C", "D", "F", "G", "I", "P", "Q" and "R". The clarification of structures of continuous attacking actions will be helpful in improving the tactical behavior. The improvement of tactical behavior may prevent the injury.

References

1. Taborsky, F. and Hoffmann, E. Attractive offensive play but shortcoming in defense. World Handball Magazine. Special Supplement II: 4-14, 2003.
2. Meletakos, P. and Bayios, I. General trends in European men's handball: a longitudinal study. International Journal of Performance Analysis in Sport. 10: 221-228, 2010.
3. Meletakos, P., Vagenas, G. and Bayios, I. A multivariate assessment of offensive performance indicators in men's handball: Trends and differences in the World Championships. International Journal of Performance Analysis in Sport. 11: 284-294, 2011.
4. Foretić, N., Rougulj, N. and Trninic, M. The influence of situation efficiency on the result of a handball match. Sport Science 3. 2: 45-51, 2010.
5. Ichimura, S. et al. Quantification of Shooting Play Position and Shooting Course from Pictorial Handball Match Statistics Report. EHF Scientific Conference 2011 Science and Analytical Expertise in Handball (Scientific and practical approaches): 261-266, 2011.
6. Carling et al. The role of motion analysis in elite soccer: contemporary performance measurement technique and work rate data. Sports Med. 38(10): 839-862, 2008.
7. Koch, C. and Tilp, M. Analysis of beach volleyball action sequences of female top athletes. Journal of Human Sport & Exercise 4: 272-283, 2009.
8. Lopes, A., et al. Ball Recovery in the Handball Tournament of the 2008 Beijing Olympic Games: Sequential Analysis of Positional Play as Used by the Spanish Team's Defence. In A.J. Spink, F. Grieco, O.E. Krips, L.W.S. Loijens, L.P.J.J. Noldus, and P.H. Zimmermann (Eds.), Proceedings of Measuring Behavior 2010, 7th International Conference on Methods and Techniques in Behavioral Research, 177-180, Eindhoven: Noldus Information Technology bv. 2010.
9. Schrapf, N. and Tilp, M. Action sequence analysis in team handball, J. Hum. Sport Exerc, 8(3): S615-S621, 2013.
10. Ichimura S et al. Proposal on the analysis of offense set-play using sequence analysis. 2nd EHF Scientific Conference Women and Handball (Scientific and practical approaches): 224-227, 2013.

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TRIGGER POINT PERFORMANCETHERAPY IN PREVENTION AND REHABILITATION

Dragos Luscan, Romanian Handball Federation

Many fitness professionals are trying now to increase the performance level of the one they train. Trigger Point Performance Therapy has brought the therapy closer to the athletes, into the court, by creating the Grid Foam Roller and Myofascial Compression Techniques. They stimulate the deep tissue and fascia and can be used in prevention, rehabilitation, before and after the practice.

Keywords : Trigger Point, Fascia, Myofascia, Foam Rolling, Myofascial Release

INTRODUCTION

Fundamentals of Myofascial Release

Whatever else they may be doing individually, muscles also influence functionability integrated body-wide continuities within the fascial webbing. Fascia is a connective tissue which is found all throughout the body. It is highly innervated which means it plays a role in kinesthetic awareness, joint stabilization and movement. Fascia is largery composed of water, which allows each layer to freely slide across one another. Inflammation or injury can begin to disrupt this enviroment and can encourage the development of adhesions which can increase the risk of injuries.

Myofascia is referring to the muscle and fascia together. This is the general term that is commonly used when reffering muscle and the fascia. The importance of naming them together is that although they may serve their respective functions, they are inseparable of each other. Muscle and fascia work together to help drive and control movement. The fascia serves to reinforce common movement patterns.

When Myofascia becomes inflamed or injured a Myofascial Trigger Point can be the result. A Myofascial Trigger Point is a hyperirritable spot in the skeletal muscle that is associated with a hypersensitive palpable nodule or tough band. A chronic or acute injury to the fascia that consistenly results in inflammation can eventually lead to thickening of the fascia results in the irritation.

Trigger Points follow a characteristic referral pattern and often form after chronic overuse. A Trigger Point can affect both the sensory and motor function of the muscle. Trigger Points often lead to:

- Decreased pain free range of motion
- Local tenderness
- Referred pain
- Increased fatigue in the affected muscle

METHODS

The Trigger Point Performance Therapy tools are *Grid Foam Rolling* and *Myofascial Compression Techniques*. The products have been made based on the needs of the sportives : to prevent better and recover recover faster, on the court, without the help of a therapist.

The GRID Foam Roller is made to feel the human hand.
Foam rolling is a form of self-induced massage which consists of using a cylindrical device to attempt to mobilize soft tissue. The foam rollers vary in terms of density and size which can play an important role in the depth of tissue effected. The larger and softer the roller is the closer to

the surface it will work. If the roller is smaller and harder it will travel deeper to influence more layers.May seem better to work deeper, but, in fact this varies per individual and the experience they have had with foam rolling. Being too aggressive too early can cause a negative response in the body.

There is no specific data as to when foam rolling began. It is speculated to have begun in the mid 1990's in physical therapist clinics due to an increase in popularity and cost of massage. Sports Massage was utilized in the 1984 Summer Olympics, and has been used in every Olympic Games since. This was the first time it was recognized as playing an important role in injury prevention and performance.

Myofascial Compression Techniques consist in a metchod of soft-tissue release designed to build compression into a targeted muscle and then use basic functional movements to re-establish ones normal range of motion. This does not occur with the traditional method of foam rolling. Different diameters of tools will vary the depth traveled into the tissue and which later is being affected. It has been suggested that myofascial release can occur by applying a low load, in a specific direction for a long period of time. Although the amount of time can vary, typically, a release can be felt. The fluid content of the myofascial network also indicates that the body will respond better to the low forces than to the more aggressive and faster paced rolling which is commonly seen.

The benefits of Trigger Point Therapy in prevention and rehabilitation
For years the majority of foam rolling benefits stemmed from research based on massage. While the effects of foam rolling may be very similar to massage, the self – application aspect of myofascial release could make a significant difference in the changes of the soft tissue. In the past five years the research considering foam rolling has increased due to growing popularity of massage and a paradigm shift towards realizing the lasting benefits of consistent soft tissue work. Colectively the researchers said that foam rolling and myofascial release appears to be beneficial before and after the practice.

Foam Rolling warm-up delays onset of fatigue
A 2013 study by K.C. Healey was focused on whether or not foam rolling would affect athletic performance. The movemets examined were a squat, assessment of jump high and an agility drill. The researchers concluded that while there was no significant difference in the performance tests, there was a significant difference in the time to fatigue. The conclusion was that foam rolling does not have detrimental effects on performance and it is used as part of a warm up.

Foam Rolling increases flexibility
The researchers tested 17 subjects looking at flexibility, muscle activation, maximum voluntary isometric contraction, knee flexion and electromechanical delay before and after four different interventions of hamstring foam rolling. The study concluded that foam rolling pre-exercise was effective at increasing flexibility measured by a sit and reach assessment, with no detriment to the force production of the hamstrings. (Sullivan, 2013)

Foam Rolling increases range of motion
In 2012, G.Z. MacDonald studied the effects of foam rolling on knee joint range of motion and the muscular force or rate of force development. The researcher found no significant difference between muscle force, rate of force development or muscular activation. But, he has noted there was a significant increase in range of motion of the knee joint. The researcher concluded that 1 minute bouts of foam rolling proved to be significant in increasing range of motion without decreasing production of muscular force or rate of force development.

Foam Rolling reduces soreness

After 2012 there were made lots of studies to assess delayed on-set muscle soreness._The study found that following up one repetition maximum testing with 60 seconds of foam rolling, the sportives has reduced muscle soreness. The conclusion was that foam rolling as part of the cool down reduce the negative effects of delayed onset muscle soreness allowing more frequent exercise sessions.

Foam rolling and static stretching

In a study made by A. D'Amico and C.Morin were compared foam rolling and static stretching as part of trying to increase tissue extensibility and joint range of motion. Static stretching is commonly used as part of cool down to help restore proper muscle length and prevent muscle soreness. After the test the autors concluded that both static stretching and foam rolling significantly improved joint range of motion. This could suggest that foam rolling is as effective as static stretching as part of cool down following exercise.

Myofascial release is the foundation of addressing most of the biomechanical restrictions.

Utilizing myofascial release is scientifically equivalent to adding water to dried clay, hence making it malleable once again and ready to be shaped towards functionability. The problem with myofascial release is that people tend to take a passive approach towards it. This is probably because many lack of initiative to push their comfort zones. When using an aggressive approach during self myofascial release to push comfort zones, the body will allow itself to develop new neurological inputs for functional patterns. As myofascial release eliminates the restrictive patterns within the body, the brain can now effectively reshape its mechanical behavior.

COMMUNICATING PAIN VS. DISCOMFORT

The body's response to pain is likely one of the most overlooked and under estimated aspects of foam rolling. Trigger Points evoke a local tenderness response, sometimes when the muscle contracts or when the areas are compressed. Compression into the area can help release the dysfunctional tissue, but it does come along with a certain amount of discomfort. While discomfort is normal, there should not be significant pain. Each person has their individual pain threshold and the way they respond to it can also differ. It is important to pay attention to facial cues and changes in breathing which may indicate the person feels more pain than the normal level.If the pain is too intense then the person will likelytense up and guard the area which will decrease the effectiveness of foam rolling.

CONCLUSIONS

Foam rolling before a session of training can improve joint range-of-motion and flexibility without a concurrent decrease in performance. This makes foam rolling ideal before training, because an increase in range of motion is correlated with less movement compensations while the reduced chance of injury and performance stays the same. Foam rolling after training has been found to reduce the negative effects of delayed onset muscle soreness. In addition, static stretching has been the norm for post-workout recovery as a method to reduce blood pooling and to help restore proper muscle length. Foam rolling was found to be as effective as static stretching for a post exercise recovery. The goal of Myofascial Compression Techniques is not to inherently release and remove the Trigger Points but to help to assess and restore normal biomechanics in an effort to reduce the need for the painful nodules. Trigger Point Performance Therapy can be a very good tool to use on the court in order to perform better.

References

1. American College of Sports Medicine. (2006). *Acsm's guidelines for exercise testing and prescription*. Baltimore, MD: Lippincott, Williams and Wilkins.
2. D'Amico, A &Morin, C. *Effects of myofascial release on human performance: A review of the literature.*
3. Healey, K. C., Hatfield, D.L., Blanpied, P., Dorfman, L.R., and Riebe, D. (2013). *The effects of myofascial release with foam rolling on performance. Journal of Strength and Conditioning Research*, retrieved from: http://www.ncbi.nlm.nih.gov/pubmed/23588488
4. Hilbert, JE, Sforzo, GA, Swensen, T. (2003) *The effects of massage on delayed onset muscle soreness*. British Journal of Sports Medicine, 37, 72-75.
5. Macdonald, G.Z., Button, D.C., Drinkwater, E.J., Behm, D.G. (2013). *Foam rolling as a recovery tool following an intense bout of physical activity*. *Medicine & Science in Sports & Exercise,* doi: 10.1249/MSS.0b013e3182a123db.
6. MacDonald, G. Z., Penney, M.D., Mullaley, M.E., and Drake, C. D. (2013). *An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. Journal of Strength and Conditioning Research,* 27 (3), 812-21
7. Myers. T, *Anatomy Trains- Myofascial meridians for manual and movements therapists*, London, England; Livingstone Churcill Elseviere
8. www.fasciaresearch.com
9. www.tptherapy.com

PREPARATION AND TRAINING OF ELITE TEAM HANDBALL PLAYERS

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Summary

Relevant physical training with sufficient volume and intensity must be performed in elite team handball for improving playing performance and for preventing overload and injuries. Even though elite team handball is a team sport, match analysis have shown that physical training in modern elite team handball should be directed at specific playing positions and individual physical capacity. Knowledge of the principles and the effects of the different types of physical training are essential for the planning of an optimal training program. The principles for aerobic, anaerobic and strength training are shortly presented here. In addition, the aspect of concurrent aerobic training and strength training is also discussed, and examples of training programmes for elite players during the competitive match season are presented.

Keywords: Match analysis, physical training, training principles, concurrent training, planning of training

Introduction

The competition in elite team handball (TH) has increased significantly in the recent decades, and the physical requirements for elite players have increased correspondingly. Knowledge of the working requirements in TH is a prerequisite for the planning and implementation of optimal training paradigms. Recent match analyses have shown that modern elite TH is a complex and physically demanding sport that is characterized by 60 min of repeated accelerations, sprints, jumps, passes, shots, side-stepping, rapid changes of direction, where the players work intensely for short, intermittent time intervals, while at the same time being tackled, grappled and pushed during a high number of physical confrontations with opponent players (Michalsik et al., 2013, 2014, 2015a,b,c; Michalsik & Aagaard, 2015). During the match, the players need a great capacity for strength and power, anaerobic performance and also a high level of aerobic power and intermittent endurance to constantly perform during the entire match, where they also at the same time continuously must be aware of the tactical game conditions. A high level of physical conditioning is an essential tool to exploit and sustain the players´ technical and tactical qualities throughout an entire game. During the 9-10 months match season, the number of competitive matches may be up to 80 for top-elite players including international tournaments. It is more common with two matches per week than one. Moreover, in international elite team handball tournaments such as the World Championships each team have to play 8-10 matches in 12-14 days (Michalsik et al., 2013). In addition to the extensive match program, the players also perform 6-10 training sessions per week (Michalsik et al., 2014).

Even though elite TH is a team sport, match analyses have shown that physical training in modern elite TH should be directed at the specific playing position and the players' individual physical capacity (Michalsik et al., 2013, 2014, 2015a,b,c). Furthermore, clear gender-specific differences in the physical demands of modern elite TH have been demonstrated, strongly suggesting that central areas of physical training should be conducted differently in female elite TH compared to male elite TH (Michalsik & Aagaard, 2015). Consequently, it is important to emphasize that the aforementioned aspects regarding playing positions, individual physical capacity and gender must be taking into consideration, while designing physical training regimens for elite TH players. Moreover, the training must to be planned with the right balance between exercise and recovery. For some players the volume and intensity of the training will be optimal, whereas for others it will be too hard. Additionally, it is not possible for elite players to be constantly at a top level during the entire competitive match season. The training must be periodized, so the players will reach the best possible performance in the most important competitions/matches of the competitive match season. The physical training should be organized with preplanned, systematic variations in training specificity, intensity, and volume in different periods or cycles within the overall training program for the season. Training programs for elite TH players should use periodization to break up the training into e.g. the off-season, pre-season, in-season (and divide it further to provide multiple peak performances during the competitive period), and the post-season, which should focus on different goals in the various periods of training. An improved level of physical capacity enables players to train at increased intensity and in achieving a large total quantity of training, and in addition will mean that the trainer will carry out substitutions during match-play first and foremost on the basis of technical/tactical considerations.

Thus, relevant physical training with sufficient volume and intensity must be performed in elite TH not only for improving playing performance, but also for preventing overload and injuries, especially for the players who play regularly. If the physical preparation of elite TH players are inadequate combined with the comprehensive match schedule, it is likely that the players will get overreached and later overloaded, which might lead to injuries. A study of female elite TH players during the competitive match season revealed that almost 40% of the reported injuries were overuse injuries, and furthermore that around 32% of the traumatic injuries occurred without any contact between players (Moller et al., 2012), which means that a specific design and implementation of sufficient and sensible physical training can indeed help to prevent overload injuries in elite TH. Additionally, specific prevention training programs including neuromuscular training have been shown to reduce the number and hence prevent injuries in elite TH (Myklebust et al., 2007). Reducing the number of injuries will indirectly help the teams to increase their performance simply because they can play with all their best players almost every match throughout the entire season.

In order to plan an effective training program, it is necessary to make use of both practical experience and evidence-based recommendations. This combination ensures the best possible foundation for qualified exercise planning. In addition, knowledge of the principles and the effects of the different types of physical training, and in addition of new training methods, are essential for the planning of an optimal training program, which can lead to better match performance and reduce the number of overload injuries. However, in this short article the focus will only be on the general principles for proper physical training in elite TH, which can increase the ability to tolerate large amounts of high quality training and to improve playing performance during repetitive training sessions and match-play, respectively.

Training principles

It is important that improvements achieved by physical training can be transferred to the actual TH game on court. Therefore, the training needs to be as functional as possible. Physical training in TH should as far as possible be performed on-court in game-like simulations (i.e. with ball handling involved), since such training has several advantages (Michalsik & Bangsbo, 2015). Firstly, the muscle coordination and the specific muscle groups used in TH will be trained. In addition, the players' technical and tactical abilities will be developed under conditions relevant to the game. Finally, training with a ball will be more motivating for most players. However, there may be circumstances where it is necessary to train physical training without the ball (formal training), e.g. if there is only limited time and space to train indoors on the court. Moreover, some players do not work hard enough with the ball, because their technical and tactical limitations lower the exercise intensity.

Aerobic training

Aerobic training can be divided into three overlapping areas: A) Low-intensity training, (B) Moderate-intensity training, and (C) High-intensity training (Michalsik & Bangsbo, 2015). The training intensity can be assessed by using measurements of the heart rate. Table 1 illustrates the principles behind the various categories of aerobic training. The relative exercise intensity is expressed as the heart rate during exercise in relation to the maximum heart rate. As aerobic training should mainly be performed with a ball, the definition of the three categories takes into account that the heart rate will alternate continuously during training, since the intensity can depend on the players´ direct involvement in the game and therefore can be difficult to control precisely. Thus, an acceptable primary area (range) is designated. The training intensity must be regulated according to the player´s own maximum heart rate (HR).

Aerobic low-intensity training should be performed to achieve faster recovery after a match or an intensive training session. Therefore, the training is also called recovery training. After such activities, the physical performance is reduced, and the typical symptom that the player experiences is local muscle soreness. During low-intensity training the players perform light physical activities such as jogging and low intensity ball games. This type of training may help the muscles to recover more efficiently and to avoid overtraining. Throughout the competitive match season, when players are training frequently and playing many matches, there may be times when the body is not able to recover completely. In such cases, low-intensity training should replace more physically demanding forms of training. During low-intensity training, the exercise intensity should be performed with a mean HR of approximately 65% of HR_{max} (see Table 1). This type of training also has psychological benefits. The need to recovery physically is often accompanied by a need to relax mentally. This may be obtained by performing exercises of low intensity and activities that differ from those normally used

Table 1. The heart rate during aerobic training. # An example with a maximum heart rate of 200 beats/minute is shown.

	Heart rate (% of HR_{max})		Heart rate # (beats/minute)	
	Mean	Range	Mean	Range
Low-intensity training	65%	50-80%	130	100-160
Moderate-intensity training	80%	70-90%	160	140-180
High-intensity training	90%	80-100%	180	160-200

Aerobic moderate-intensity training aims to increase the capacity to exercise for prolonged periods of time, i.e. for the entire match, and to increase the ability to recover quickly after a period of high-intensity exercise during training or match-play, and in addition between multiple training sessions or matches in long tournaments. A male/female elite TH player covers around 4 kilometres during approximately 50 minutes of match-play and also performs other demanding activities (Michalsik & Aagaard, 2015). Therefore, elite TH players need to train the aerobic intermittent endurance capacity to be able to maintain a high work-rate and good technical performance throughout the entire match. Moderate-intensity training can take the form of either continuous or intermittent exercise. For the intermittent exercise, the work periods should be longer than 5 minutes interspersed with short breaks. During moderate-intensity training, the exercise intensity should be performed with a mean HR of approximately 80% of HR_{max} (see Table 1). As the intensity is relatively low, it is most common to conduct the training continuously. Natural fluctuations in exercise intensity during moderate-intensity training sessions will occur when the training is performed with a ball on the court.

If the training is performed without a ball, i.e. by formal continuous running, numerous studies have demonstrated that it is possible achieve the same or a further improvement in the aerobic endurance capacity by the implementation of a relatively small training volume performed with relative high intensity as by performing a larger training volume with a relatively low intensity (Laursen, 2010; Enoksen et al., 2011; Green et al., 2013). Elite TH players can benefit greatly from training with short and frequent runs with relatively high intensity within the area of aerobic moderate-intensity training (70-90% of HR_{max}), and at the same time save some valuable training time, which can be used for other aspects of training.

The purpose of *aerobic high-intensity training* is to increase the aerobic power (maximum oxygen uptake, VO_2-max) for improving the ability to exercise at a high intensity for relatively long periods of time during training or a match-play. Furthermore, the aim is also to increase the ability to recover quickly from high-intensity exercise during training or match-play. During a match, the players are exercising several periods at a high-intensity (Michalsik et al., 2013, 2014). Consequently, it is important for elite players with a well-developed capacity to perform aerobic exercise (high maximum oxygen uptake), which can be attained by aerobic high-intensity training. During the training, the lactate producing energy system may also be highly stimulated for shorts periods of time, which means that the training overlaps with anaerobic speed endurance training. During aerobic high-intensity training, the exercise intensity should be performed with a mean HR of approximately 90% of HR_{max} (see Table 1) and in the area of 80-100% of VO_2-max.

When using ball games for aerobic high-intensity training, the exercise intensity for a player varies continuously, as a player near the ball often exercises with high intensity, while the intensity is usually somewhat lower, if the ball is not close to the player or briefly out of play. However, a decrease in intensity for a short period of time will only cause a minor decrease in heart rate. Therefore, it is possible for a player to maintain a heart rate of 90% of maximum heart rate or above for the majority of the training. High-intensity aerobic exercise (formal or with ball handling) can be carried out continuously or intermittently (by interval training). Most players prefer the latter method, since it is by performing interval training easier to obtain a large total amount of intense exercise.

Performing continuous training, the training sessions should have a duration less than 30 minutes, since the intensity needs to be high. The interval training within aerobic high-intensity training can be divided into long and short interval periods (Michalsik & Bangsbo, 2015). At *long intervals*, the duration of the work periods are 2-10 minutes, and the duration of the rest/active recovery periods are 1-6 minutes. Examples of combinations of exercise/rest periods during formal training (i.e. running training) are 3/1 minutes, where the intensity of exercise periods are in the lower part of the primary area for aerobic high-intensity training and 3/3 and 6/4 minutes, where the intensity is in the high part of the primary area. The duration of the rest/active recovery periods is of less significance for the training effect, but it must be sufficiently long so that the player is able to maintain the intensity during the exercise periods.

At *short intervals*, the duration of the exercise periods are 10-120 seconds, and the duration of the rest/active recovery periods are 5-60 seconds. Examples of combinations of exercise/rest periods during formal training (i.e. running training) are 20/10 seconds, 45/20 seconds, 70/30 seconds and 90/45 seconds. During short interval training, the exercise periods can be too short for the oxygen uptake and heart rate to reach the desired level. Thus, the rest/active recovery period is crucial for the training effect. If this period is limited in time in relation to the exercise period, the oxygen uptake will only decrease to a limited degree during the break. At the start of the next exercise bout, the oxygen uptake will therefore be increased, and the oxygen uptake can thus reach a higher level during the next exercise period.

When the training is conducted with the ball, the ratio between the duration of exercise and rest/active recovery during long and short interval training, respectively, can often be reduced compared to the values presented above, since the players not constantly are working with high intensity due to natural variations in the game.

Anaerobic training

Anaerobic training can be divided into two main training areas called speed training and speed endurance training. The latter training can be divided further into production training and maintenance training (see Table 2) (Michalsik Bangsbo, 2015). The benefits of anaerobic training for elite TH players are an improved performance of intense match activities such as accelerations, change of directions, jumps, shots and tackles, and in addition an elevated ability to perform very high-intensity exercise more frequently and for longer time periods. As in aerobic training, the three training areas are overlapping. However, they are all performed with a much higher intensity, i.e. with an intensity corresponding to over VO_2-max. Consequently, all anaerobic training must be performed according to the interval principle. Furthermore, large quantities of anaerobic training should only be performed at an elite level, since it is a physical and mentally demanding type of training. Since the effects of anaerobic training only occur in the muscles used during training, all anaerobic training in elite TH should be performed with a ball, i.e. conducted in a manner similar to actual TH match-play.

The aims of *speed training* are to increase the ability to perceive match situations, to take immediate actions when needed, and finally to increase the ability to rapidly produce force during high-intensity exercise. During speed training, the players should perform maximally each time for less than 10 seconds. The periods between the exercise bouts should be long enough for the muscles to recover to near resting conditions to enable the players to perform maximally in subsequent exercise bouts. Speed training should be performed in the beginning of the training session when the players are not tired and after a proper warm-up. Speed training should mainly be performed as functional speed training instead of formal speed training without a ball, since part of the desired training effect is to improve the player's ability to anticipate, evaluate and decide in different situations in TH, e.g. the start signal could be the completion of a shot or the bounce of a ball. Match analyses of elite TH have shown that speed training in TH primarily should target reaction speed and acceleration capacity (i.e. rate of force development, RFD) rather than focus on maximum running speed (Michalsik et al., 2013, 2014).

Table 2. The principles for formal anaerobic training. The exercise intensity is expressed in percentage of the maximal exercise intensity. When the training is conducted with the ball, the ratio between the duration of exercise and rest/active recovery can often be reduced compared to the values presented, since the players not constantly are working with high intensity due to natural variations in the game.

Training area	Duration		Exercise intensity	No. of repetitions
	Exercise (s)	Rest		
Speed training	2-10	> 10 times exercise	100%	2-10
Production training	10-40	> 10 times exercise	60-100%	2-10
Maintenance training	10-120	1-5 times exercise	30-100%	2-15

The purpose of *production training* to increase the ability to rapidly produce power and energy via the anaerobic energy-producing systems, and thus improve the ability to perform maximally for a relatively short period of time, whereas the aim of *maintenance training* is to increase the capacity to continuously produce power and energy through the same energy systems, and hereby improve the ability to sustain exercise at a high intensity. Findings of high blood lactate concentrations in elite TH players in connection with tournament matches (Michalsik et al., 2015c) indicate that the lactate producing system is highly stimulated during certain periods of the game. Moreover, match analyses of elite TH have revealed that the amount of high-intensity running may be very high in brief time intervals, and furthermore that indications of temporary fatigue and impaired physical performance have been observed, reflected by e.g. the reduced amounts of high-intensity running and technical playing actions in the second half (Michalsik et al., 2013, 2014, 2015a). Additionally, the ability continuously to change pace and accelerate throughout the entire match appears to be of high importance for top-level playing performance in TH. Consequently, *speed endurance training* must be an integrated part of the physical training for elite TH players.

In production training, the duration of the exercise bouts should be relatively short (10-40 seconds), and the rest periods in between should be comparatively long (2-7 minutes) in order to maintain a very high intensity throughout the training. In maintenance training, the exercise periods should be 10-120 seconds, whereas the duration of the rest periods should only be the same or a little longer than the exercise periods, if the training is performed with a ball, so that the players become progressively fatigued. *Speed endurance training* should be performed at the end of the training session, because the training is so demanding that players will be physically affected for a long time afterwards.

Strength training

The body anthropometry in elite TH has increased during the last decades, and recent match analyses confirm the gradual development of today's tall and heavy male and female elite TH players with large muscle mass (Michalsik al., 2015a,b). Based on these recent match analyses of the technical playing actions in elite TH, and in addition of analyses of the locomotive characteristics (Michalsik et al. 2013, 2104), it seems desirable with a strong focus on various aspects of strength training in the light of the apparent high demand for rapid force capacity (i.e., high rate of force development, RFD) during fast and hard shots, the need for rapid body accelerations and changes of direction, and the high number of physically demanding confrontations (i.e., tackles, screenings, claspings, and blockings). Consequently, strength training must be a paramount part of the physical training of elite TH players for both men and women.

There are different needs for various players in relation to not only the specific playing positions and the individual physical capacity, but also to the different periods of the season. Some players need to gain muscle mass, which should primarily be developed and trained as *hypertrophy training* in the post- and pre-season period, respectively. This training comprises a large total volume of strength training with many exercises, and many sets and little rest between sets and exercises. This seems to induce fatigue, which may be very important for muscle growth. Some players just need to be stronger and therefore has to perform *maximal strength training*, while most players want to become more explosive and peak their performance by conducting *RFD-training*, i.e. performing few repetitions with heavy loads, and long rest between the relatively few sets and exercises. This training should be periodized during the tournament period to promote peaks in strength performance at important matches and tournaments.

Concurrent with the anthropometric development towards heavier and taller players, it becomes vital for elite TH players to sustain their functional capacity on the playing court (i.e., agility and sprint/jump/endurance abilities). Thus, players have to preserve or even improve their acceleration capacity, ability to perform rapid side-cutting manoeuvres, maximum jump height and mobility as well as aerobic power despite at the same time becoming heavier (more muscular) to push away in a breakthrough and to more effectively tackle opponent players in defence. Consequently, specific *functional strength training* regimens to improve these capacities should also be implemented, which may include e.g. on-court sprinting, maximal vertical jumping drills, and tackles and blocks performed as game simulations.

Concurrent aerobic training and strength training
Elite TH imposes high demands on a variety of physical elements, e.g. aerobic power, maximal strength and anaerobic capacity ((Michalsik et al., 2013, 2014, 2015a,b,c). As all these aspects need to be trained during the whole season, it is possible that the training adaptations are different from those obtained when the different types of training is conducted separately. In elite TH, different types of training are often performed during the same training session, the same day or the same training period, respectively. This applies especially to aerobic training and strength training. *Concurrent aerobic training and strength training* can be planned in several ways, depending on the players´ overall objective of the training. It can be performed concurrently during the same training session or on one day by splitting the training into two, e.g. with aerobic training in the morning and strength training in the evening. Furthermore, the various types of training can be placed on different days, for example with aerobic training on Mondays, strength training on Tuesdays, etc. By training periodization, certain periods can contain mostly aerobic training, while other periods may focus mostly on strength training.

There is a great need for muscle growth and large muscle strength in elite TH. If elite players combine their strength training with aerobic training in a period, the increase strength will be reduced compared to if they only trained strength training (Rønnestad & Mujika, 2014). However, it is important to note that when the training frequency, intensity or duration of the individual aerobic training session is reduced, the degree of negative interference between the two types of exercise decreases. Cycling seems to be somewhat less disruptive to strength adaptations compared to running. However, elite TH players should primarily train by running, not by cycling. The order in which the aerobic training and strength training is conducted, when they are included in the same training session, is important. It is partly due to the fatigue that has occurred after the first type of training may interfere with the ability to perform in the subsequent training, whereby reducing the quality of the final training and thus of the total training session (Kang & Ratamess, 2014). Recommendations regarding the optimal training order depend on what type of training that is most important for the individual player. Aerobic training and strength training should as far as possible not be included in the same training session for elite TH players, and there should optimally be 6-8 hours of recovery after intense aerobic training before strength training is performed (Wilson et al., 2012). Additionally, is important to consume carbohydrates after an aerobic high-intensity or long-lasting moderate-intensity training session, if strength training is to be performed later in the day.

Planning of training for elite TH players
Results from scientific studies may enable a better understanding of the demands and limitations of physical performance in TH. Such knowledge combined with practical experience provides a good basis for the planning of optimal training programmes. In a typical week for an male professional top-elite handball team with one match to play, the players should have 7-8 training sessions in 5 days (i.e. 2-3 days with two sessions), often with the day after the match free. If there is a second match in midweek, the team should train only 1-2 days with two training sessions to ensure proper recovery, while at the same time trying to peak playing performance for important matches. However, there are substantial variations depending on the training status of individual players and the experience of the coach. Examples of programmes for an international top-class handball team during the regular competitive match season are presented in Table 3.

Table 3. An in-season weekly programme for a professional male top-elite team handball (TH) team when playing one or two tournament matches a week.

Day	One match a week	Two matches a week
Sunday	Match	Match
Monday	Free or recovery training	*Morning* TH training with high-intensity running exercises, 60-90 min *Afternoon* Individual physical training - primarily strength training (RFD-training), 60 min
Tuesday	*Morning* Individual physical training - primarily strength training (RFD-training), 60 min *Afternoon* TH training with anaerobic tolerance training, 90-120 min	Tactical/technical TH training with jump training, 90 min Physical training for selected players
Wednesday	Tactical/technical TH training with jump training, 90 min Physical training for selected players	Match
Thursday	*Morning* Individual physical training - strength training (RFD-training), 60 min *Afternoon* TH training with anaerobic production training, 90-120 min	TH training - individual physical needs (a lot playing time/less playing time in yesterday´s match), 60-90 min
Friday	*Morning* TH training with high-intensity running exercises, 90-120 min *Afternoon* Individual physical training - primarily strength training (RFD-training), 60 min	*Morning* TH training with anaerobic production/tolerance training, 90-120 min *Afternoon* Individual physical training - primarily strength training (RFD-training), 60 min
Saturday	Tactical/technical TH training, 90 min Physical training for selected players	Physical training for selected players, 60-90 min or free
Sunday	Match	Match

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POST-EXERCISE RECOVERY TECHNIQUES AND STRATEGIES IN ELITE TEAM HANDBALL

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Summary
In team handball, elite players are required to perform constantly at a high level during the 9-10 months competitive match season. Consequently, players and coaches continuously seek for new methods that may improve performance and reduce fatigue and the number of overload injuries among the players who play regularly, since the recovery time between matches may be too short. Thus, the rate and quality of recovery from training and matches is extremely important in elite team handball. Numerous recovery interventions are used to enhance recovery including sleep, hydrotherapy, active recovery, stretching, compressions garments, electrostimulation, massage and nutrition or various combinations.

Keywords: Competitive demands, overload injuries, recovery time, recovery interventions, hydrotherapy

Introduction
In elite team handball, the players work intensely for short, intermittent time intervals during the sixty minutes of match-play, while frequently performing different types of locomotion and technical match activities, e.g. powerful upper body movements such as maximal ball throwing, tackles and screenings of opponents as well as forceful lower limb muscle actions during vertical jumping, sideways running, backwards running, forward sprinting, and changes of direction with a high number of physical confrontations with opponent players (Michalsik et al., 2013, 2014, 2015a,b,c; Michalsik & Aagaard, 2015). Thus, the physical demands during match-play are very high for both male and female elite players. In addition, elite players are required to perform constantly at a high level during the 9-10 months competitive match season, despite of the effects of their hard training and match schedules. The number of competitive matches may be up to 80 per season for international top-elite players. During the season, it is often more common with two matches per week than one. Moreover, in international elite team handball tournaments such as the World and the European Championships each team normally play 8-10 matches in 12-14 days (Michalsik et al., 2013).

Consequently, players and coaches constantly seek for new methods that may improve playing performance, e.g. more optimal training regimens. A single match may lead to acute fatigue, and in addition the repetition of two matches or more per week may lead to a persisting fatigue and overload injuries among the players who play regularly, since the recovery time between matches may be too short. Studies of elite female team handball players have shown that almost 40% of the injuries in a competitive match season were overuse injuries (Moller et al., 2012). This percentage perhaps was even greater, since around 32% of the traumatic injuries occurred without any contact between players. Thus, the rate and quality of recovery from exercise is also extremely important for high performance in elite team handball, and optimal recovery may provide numerous benefits during repetitive high-level training and long tournaments. Recovery aims to restore physiological and psychological processes, so that the players can compete or train again at an appropriate level as quick as possible. Furthermore, finding suitable recovery strategies to shorten recovery time between training sessions or matches may improve the possibility of safely increasing training loads, and thus performance.

Recovery from training and matches is complex and is typically dependent on the nature of the training/game (intermittent exercise, volume, intensity and duration) and outside stress factors such as health, lifestyle, nutrition, psychological stress and environment (see Table 1). There are numerous recovery interventions that are used to enhance recovery. In elite team handball, their use will depend on the amount of time until the next training or match, and on the equipment or personnel available. Some of the most popular recovery techniques for all athletes include sleep, hydrotherapy, active recovery, stretching, compressions garments, electrostimulation, massage and nutrition or various combinations. The different recovery techniques are shortly presented here. Additionally, various recovery strategies are described in other sports, since the amount of studies regarding post-exercise recovery in elite team handball are highly limited. Thus, many healthcare and rehabilitations professionals in team handball are still relying on their accumulated experience and anecdotal evidence.

Table 1. Factors affecting playing performance in team handball. Adequate recovery should also consider these factors.

Factors affecting playing performance in team handball	
Training/match-play	Volume, intensity, duration, intermittent exercise, degree of fatigue, recovery from previous training/match-play.
Health	Illness, infection, injury, muscle soreness and damage.
Lifestyle	Quality and amount of sleep, work or study situation, housing situation, relationship with team members, coach, friends and family, leisure/social activities.
Nutrition	Carbohydrate, protein and other nutrient intake, fluid and electrolyte balance.
Psychological stress	Stress and performance anxiety.
Environment	Temperature, humidity, altitude.

Recovery techniques

Sleep

It is generally accepted that sleep serves to recover from previous wakefulness and/or to prepare for functioning in the subsequent wake period. The recent sleep history of an individual therefore has a marked impact on him/hers daytime functioning including the practice of sports. Restricting sleep to less than 6 hours in several consecutive nights has been shown to impair cognitive performance and various physiological functions. This has led to the recommendation that adults should obtain 8 hours of sleep per night. However, there are limited data related to the amount of sleep obtained by athletes.

A way of examining the effect of sleep on performance is to extend the amount of sleep an athlete receive and determine the effects on subsequent performance. It seems that the increasing amount of sleep may significantly enhance athletic performance including e.g. technical skills and reaction time (Mah et al., 2011). Athletes, who suffer from some degree of sleep loss, may benefit from a brief nap, particularly if a training session is going to be completed in the afternoon or evening. Napping may be beneficial for athletes who have to wake early for training/competition, and for athletes who are experiencing sleep deprivation. Studies has revealed that athletes experience sleep disturbances and poor sleep during normal training periods (Leeder et al., 2012b) and especially prior to important competitions (Erlacher et al., 2011). The former may be due to e.g. poor routines as a consequence of early training sessions or poor sleep habits, and the latter may be due to factors like thoughts and nervousness about the competition.

Playing a team handball match in the evening (around 8-9 pm.) impose high physical and mental loads on the players. Additionally, post-match routines (medical care, recovery strategies, meal and perhaps return trip) often lead to a late bedtime, which may influence sleep quality and quantity. Sleep loss is associated with reduction in endurance performance, maximal strength and cognitive performance (Reilly & Edwards, 2007). A poor night's sleep may be compensated by a short post-lunch nap. Studies have demonstrated that a nap followed by a 30-minute recovery period improved mental and physical performance aspects following partial sleep loss (Waterhouse et al., 2007). Player's ability to nap for short periods may be a useful skill particularly during congested schedules. Another strategy to improve physical performance could be to extend sleep quantity over several weeks and to adopt good sleep habits (see Table 2). Sleep has a positive impact on the recovery process and is an essential part of a good recovery strategy. Team handball players should focus on utilising good sleep hygiene to maximise sleep.

Table 2. Strategies for good sleep for athletes including team handball players.

Practical applications for sleep
The bedroom should be cool, dark and quiet. Eye marks and ear plugs can be useful, especially during travel.
Create a good sleep routine by going to bed at the same time and waking up at the same time.
Avoid watching television in bed, using the computer in bed and avoid watching the clock.
Avoid caffeine approximately 4 to 5 hours prior to sleep - this may vary between individuals.
Do not go to bed after consuming too much food as it may result in waking up to use the bathroom.
Napping can be useful, however generally naps should be kept to less than 1 hour and not too close to bedtime as it may then interfere with sleep.

Hydrotherapy

Although hydrotherapy is widely used as a post-exercise recovery technique, most knowledge about this intervention is anecdotal. However, more research has been published recently regarding water immersion, recovery and performance. This recovery technique results in changes in the heart, blood flow as well as skin, core and muscle temperature alternations, which may have an effect on inflammation, immune function, muscle soreness, perception of fatigue and performance (Wilcock et al., 2006). The most common forms of water immersion are cold water immersion (CWI), hot water immersion (HWI) and contrast water therapy (CWT), where the athlete alternates between hot and cold water immersions.

The effect of all three hydrotherapy interventions together with passive recovery on next day performance recovery was investigated on male cyclists following 5 consecutive days of high-intensity exercise. The performance and the recovery from high-intensity cycling were enhanced across the 5-day trial following CWI and CWT when compared to HWI and passive recovery (Vaile et al., 2008a). In another study, the same authors showed that different water immersions protocols improved subsequent cycling performance in the heat when compared to active recovery, demonstrating the positive effects of CWI for athletes exercising in the heat (Vaile et al., 2008b). Other studies of recovery techniques on cyclists and runners have demonstrated positive effects of CWT when compared to passive recovery (Versey et al., 2011, 2012). The ratio of hot (35-40 °C) vs. cold water during CWT should be 1:1, e.g. seven rotations of one minute of hot and one minute of cold water.

Several meta-analyses have confirmed the benefits of CWI of recovery on performance (Leeder et al., 2012a; Poppendieck et al., 2013). Also in relation to anaerobic performances, e.g. maximal strength, sprinting ability and countermovement jumping, CWI has proved to be effective for improving performances (Ingram et al., 2009; King & Duffield, 2009). CWI has also been found to reduce the onset of muscle soreness after exercise (Bleakley et al., 2012). It seems that the performance change associated with CWI is higher in weight-bearing sports like running and weight lifting compared to non-weight-bearing sports such as swimming and cycling. The positive effects of CWI on recovery of exercise are higher when physical confrontations leading to muscle damage are involved *(*Pointon & Duffield, 2012). A recommended protocol for CWI to optimise the effects of recovery on performance in team handball could be: Whole-body immersion lasting 10 to 20 minutes at a temperature of 12-15 °C immediately after a match or high-intensity training (Halson, 2011; Poppendieck et al., 2013). It appears that hydrotherapy may be beneficial for athletes including team handball players, since the latter players perform high-intensity exercise with many physical confrontations during both training and match-play. Specifically, CWI and CWT seem more beneficial than HWI for the recovery of exercise.

Active recovery

This recovery technique consists of aerobic exercise that can be performed using different kinds of activities such as running, biking, aqua jogging, swimming or rowing at low intensities for 15-30 minutes. In ball games e.g. soccer, it is sometimes implemented after hard training sessions or matches performed as running at an intensity of 30-60% of VO_2-max (corresponding to a heart rate under 150 beats/ minute at a maximum heart rate of 200 beats/minute) for at least 15 minutes or as ball games that does not place great demands on the players. Active recovery is normally believed to be better for recovery than passive recovery due to enhanced blood flow and hence increased oxygen delivery to the exercising areas. Studies have shown increased blood lactate removal after active recovery in comparison with passive recovery, and that lactate clearance is higher at active recovery at 50% of maximal power out compared to active recovery of lower intensity (25% of maximal power output) (Riganas et al., 2015). However, lactate removal should not be the primary indicator of the quality of recovery and the ability to repeat performance at previous level.

Active recovery is anecdotally reported to be one of the most common forms of recovery techniques and is utilised by many athletes for its role in reducing lactate concentration and reducing muscle soreness after exercise. However, faster lactate removal does not necessarily results in better performance in subsequent exercise. At present, it is not clear whether there are benefits of active recovery between training sessions or following competition in various sports. Studies have shown conflicting results on the effects of active recovery on performance. This is perhaps due to the amount of time that elapses between the end of the training/competition and the beginning of the active recovery activity. Notably, no detrimental effects of active recovery have been reported following active recovery when compared to passive recovery.

One study of soccer players revealed that a group of players, who performed an active recovery program of 20 minutes immediately after soccer matches, had a smaller reduction in e.g. jump abilities two days after the matches compared to players who did not perform any form of active recovery (Rey et al., 2012). In contrast, a set of studies on recovery between two soccer matches separated by three days showed that active recovery performed 22 and 46 hours after the first match had no effects on the recovery pattern of performance markers such as countermovement jumping and 20 meter sprint performance and perceived muscle soreness (Andersson et al., 2008, 2010).

Stretching

Athletes devote a substantial amount of training and match preparation time to stretching. According to studies in The English Premier Football League, the clubs use almost 40% of their training time to flexibility training (Dadebo et al., 2004). Stretching exercises are performed to improve range of motion, to reduce musculotendinous stiffness and to prevent injury. In addition, it is also one of the most used recovery techniques. However, there is limited literature and scientific evidence to support of the use of stretching to promote the post-exercise recovery of athletes. In a meta-analysis of numerous studies, no effect of stretching in reducing muscle soreness in the days following exercise was reported (Herbert et al., 2011). Other reviews of recovery methods concluded that there were no benefits for stretching as a recovery modality (Vaile et al., 2010; Barnett, 2011). In addition, studies demonstrated no effect of stretching on the recovery of physical performance (Lund et al., 1998). However, it is also important to note that no detrimental effects on performance associated with post-exercise stretching have been found.

Compression garments

Compression garments is a therapy normally used in patients. It has traditionally been used to treat various lymphatic and circulatory conditions. The principle of compression clothing is to increase the venous return by increasing e.g. the pressure on the ankle and decrease it on the mid-thigh and thereby reduce venous statis in the lower extremities. The external pressure created may reduce the intramuscular space available for swelling and promote stable arrangement of muscle fibers, diminishing the inflammatory response and reducing muscle soreness. Compression clothing used by athletes includes socks, shorts, tights and full compression body suits. A meta-analysis of 12 studies on the recovery following damaging exercise primarily in the lower part of the body with variables measured 24, 48 or 72 hours post-exercise indicated that the use of compressions garments had a moderate effect on recovery of muscle strength, muscle power and in reducing the severity of delayed onset of muscle soreness (DOMS) (Hill et al., 2014). Notably, as a potential study limitation in most of the studies, the actual pressure applied by the garments to the subjects was not measured. In conclusion, the use of compressions garment may be beneficial and provide an easy-to-use recovery strategy - also for team handball players, especially during air travel. Furthermore, they do not appear to be harmful to the recovery process. However, more studies are needed to evaluate the effect of the various forms of compression garments on the recovery process on different groups of athletes.

Electrostimulation

Electrostimulation involves the transmission of electrical impulses via surface electrodes to peripherally stimulate motor neurons through the skin. As a consequence, muscular contractions will emerge. Electrostimulation is mostly used for recovery purposes. In a review of several studies, the authors failed to find any effect of electrostimulation on the ability to maintain performance after exercise (Babault et al., 2011). However, in some studies a significant effect of electro-stimulation on the reduction of muscle soreness was reported. In conclusion, no scientific evidence exists regarding the ability of electrostimulation to maintain physical performance. Furthermore, the amount of studies concerning on the positive effects on subjective ratings such as muscle soreness is highly limited.

Massage

Massage is widely used as a recovery technique among athletes who often experience benefits of massage on subjective symptoms of delayed onset of muscle soreness (DOMS) (Hemmings et al., 2000). However, in terms of recovery of performance, most studies have shown no positive effects of massage on subsequent exercise performance (Robertson et al., 2004; Barlow et al., 2007). Increased blood flow to the muscles is one of mechanisms proposed to improve recovery due to enhanced clearance of metabolic products. Furthermore, massage therapy attenuates inflammatory signalling after exercise-induced muscle damage (Crane et al., 2012). Nevertheless, reviews of the effects of massage have found that almost no studies support massage as a recovery technique for improving recovery of functional performance (Weerapong et al., 2005; Barnett, 2006). Instead, massage is beneficial in enhancing the psychological aspects of recovery and may have potential benefits for injury prevention and treatment. For these reasons, it should still be included in a training programme for team handball players with 1 to 2 massage treatments per week for the elite player depending on the tournament phase and the number of matches/trainings.

Nutrition
Rehydration, carbohydrate and protein consumption after training or match-play are effective recovery techniques for refilling water and substrate stores and optimising muscle damage repair. However, the quantity and timing are very important to maximize their effectiveness. Complete restoration of fluid balance is crucial as loss of intracellular volume reduces the rates of glycogen and protein synthesis (Nédélec et al., 2013). Moreover, the addition of sodium to rehydration beverages is recommended, since it promotes fluid retention, stimulates the thirst while delaying urine production and increase glucose absorption in the small intestine (Shirreffs & Maughan, 2000). It is also recommended to drink a large volume of fluid after training/match instead of small quantities gradually, since a high rate of post-exercise fluid consumption results in a faster fluid balance restoration compared to a low rate of fluid intake (Kovacs et al., 2002). Furthermore, addition of a small amount of carbohydrate into the water can also be advised as it stimulates fluid absorption in the gut (Shirreffs & Maughan, 2000). Finally, alcohol consumption should be avoided.

The time course of muscle glycogen repletion after e.g. an elite soccer match is between 2 or 3 days. To optimise the resynthesis of muscle glycogen, an intake of ~1.2 g carbohydrate per kilo per hour with a high glycemic index immediately after a match and at 15-60 minutes intervals for up to 5 hours afterwards is recommended for soccer players (Jentjens & Jeukendru, 2003). This enables maximum resynthesis of the muscle glycogen stores. If such amount of carbohydrate intake is necessary in elite team handball is questionable due to e.g. much lesser playing time. However, no study has ever measured the glycogen consumption during match-play or training in team handball.

The absence of protein intake after exercise can lead to a negative net protein balance. A positive protein balance is required to repair exercise-induced muscle damage following a team handball match or training. The quantity, type and timing of protein ingestion to maximise post-exercise muscle protein synthesis remains topics for debate. However, consumption of ~20 g milk protein or an equivalent of ~ 9 g essential amino acids seems to be sufficient to stimulate muscle protein synthesis rates during the first two hours of post-exercise recovery (Beelen et al., 2010). A high protein diet after exercise can also improve subsequent muscle function (Cockburn et al., 2008) and the physical performance (Saunders et al., 2004). Several studies have confirmed positive effects of post-exercise chocolate and flavoured milk supplementation on subsequent exercise performance (Pritchett et al., 2009; Ferguson-Stegall et al., 2011). Some juices such as tart cherry juice and tomato juice are also recommended for enhancing the recovery process due to e.g. a high antioxidant capacity and a content of melatonin, which has a positive effect on sleep quantity and quality (Howatson et al., 2012).

Post-exercise recovery strategies in elite team handball
Finally, an example of a practical post-exercise recovery strategy based on scientific evidence in elite soccer is shortly described here, which most likely can to transferred to elite team handball, since the

two ball games have many similarities. This recovery protocol includes six steps and should start immediately after the match/training.

The first step is hydration. The mass of the players should be measured and compared to the pre-match body mass in order to propose the appropriate quantity of fluid to drink. The fluid should contain a combination of water and a large amount of sodium (500 to 700 mg per liter of water). The second step consists in drinking a tart cherry juice and chocolate milk in order to restore glycogen, to reduce oxidative stress and inflammation, to stimulate muscle repair and to promote the quality and quantity of sleep. The third step is a cold bath (CWI). The players should immerse themselves up to the neck at a temperature 12-15°C for 10-20 minutes to accelerate the recovery process. The fourth step is to wear a compression garment until bedtime. The fifth step is to eat a meal high in carbohydrate with a high glycemic index and protein within 1 hour after the match. The final step is to have a good night's sleep.

Conclusions

As recovery techniques and strategies are relatively new research areas, many of the current recommendations are general guidelines only. Indeed, scientific data of recovery strategies specific for team handball is totally lacking. Although it remains important to isolate each technique to determine its effects in future research, it would also be interesting to analyse the interactions between the different techniques. However in conclusion, recovery techniques such as sleep, hydration, diet, cold-water immersion and compressions garments are effective in accelerating the recovery process and should be implemented by healthcare and rehabilitations professionals in elite team handball to enhance training and performance.

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A CASE STUDY OF THE EFFECTS OF INTERVENTION ON PHYSICAL TRAINING OF FEMALE JAPANESE JUNIOR HANDBALL PLAYERS

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SUMMARY
The objective of this study was to investigate the effects of long-term intervention on the physical training of female, middle-ranking, Japanese junior handball players in order to observe their physical development. Our investigation of the players who continued physical training for 3 years indicated that they experienced significant improvements in muscular strength and power, throwing ability, and aerobic capacity.

Keywords: handball, physical training, intervention, junior players

INTRODUCTION
It is often known that within a handball match the ability to run, throw and jump is necessary. Within the rules of handball heavy bodily contact is tolerated, resulting in core strength, stability and flexibility being seen as essential. When looking at young players playing at an advanced level, it is natural for not only the improvement of physical strength, but also the prevention of injury within physical training to be planned and continually assessed. However, it is difficult to continually assess the physical history of junior players in Japan. The reason being, in Japan each school has a separate handball team, meaning for 3 years in middle school, 3 years in high school and 4 years in university, it is not unusual for players to play for a different team when changing school. Although, junior players in Japan must take a general health examination and physical test within schools, there are no physical tests within handball clubs. Coaches (or teachers) are not accustomed to the fact that physical tests will be useful in regards to team management. In order to efficiently strengthen a team, not only the usage of physical strength measurement to make evident the result of daily physical training, but also the early prevention of injuries that often occur within junior players is necessary.

Incidentally, in recent years there have been numerous accounts of research reporting on the result of physical strength training on junior players. Shahram A. et al. (2012) has verified on the result of plyometric circuit exercise on junior handball players in Iran, including the improvement of jump strength. Christian R. et al. (2015) has verified on the result of medicine ball training on female handball players, confirming the improvement of throwing speed. Examination on the effectiveness of core training has also been carried out (Atle H. S. et al. 2011). There is also intervention research for the purpose of improving sprinting ability that has yielded good results.
The objective of this study was to investigate the effects of long-term intervention on the physical training of female, middle-ranking, Japanese junior handball players in order to observe their physical development.

METHODS

Subjects:

The subjects were 33 female junior handball players aged 15 to 18 years who were members of teams that participated in competitions throughout Japan. The experience of the players ranged from playing handball for the first time to playing in the national U15 games. The 4-year observation period was from 2010 to 2014. Each year in July, official physical examinations were conducted by the Japan Handball Association. Six subjects were observed for 3 continuous years, and 21 subjects, for 2 continuous years. Prior to the study, detailed descriptions of the study objectives, and types of intervention and measurements to be performed were provided to the school principals, coaches, and players before obtaining their informed consent.

Types of intervention:

In order to observe the junior players' physical development, the players continuously practiced certain types of physical training until they became competent. They did not practice the physical training during training periods for competitions, tournaments, and their time off (approximately 1 week) after competitions and tournaments. They were also given time off on Japanese national holidays (3- to 5-day periods) during the summer and winter. Their daily practice consisted of 1 hour of physical training 6 times per week, before and after ball exercises. The objectives of this physical training were to develop running, throwing, jumping abilities and core strength in order to build up endurance in intense contact. The details are as follows:

1) Daily: Footwork drills
2) Every other day: The subjects selected 2 to 3 of the following: 20/40/20-m sprint training or repetitively running 700 m, jump training (including plyometric exercise), 3kg medicine ball throwing, and core training with their own weight.
3) Once or twice per week: Free weight training

Physical measurements:

The physical measurements were those conducted as part of the Japan Handball Association National Training System. The details are as follows:

1) 30m straight sprint test (30m SS; sec.)
2) 30m changes of direction sprint test (30m CDS; sec.)
3) Standing long jump (SLJ; cm)
4) Standing three steps long jump (STSJ; cm)
5) Side steps (; freq.)
6) Sitting handball throwing (SHT; m)
7) Straight leg rising test (SLR; angle)
8) 20m shuttle running (20m SR; freq.)
9) 3kg Medicine ball throwing (MBT; m)
10) Hand grip (; kg)
11) Back strength (; kg)
12) Sit ups (; freq.)

Statistical analysis:

The subjects were categorized according to high-school year level defined as follows: first year, 16 years old (range, 15–16 years old); second year, 17 years old (16–17 years old); and third year, 18 years old (17–18 years old). The *t* test was used to compare the results of 1-year training, and one-way analysis of variance was used to analyze the results of 2-year training. Correlations between the measured values were calculated by using the Pearson product-moment correlation coefficient.

RESULTS and DISCUSSION

In regards to the physical proportions of players that participated in this study, the average height saw an increase from 159.6 cm to 162.4 cm within the time – period of 16 to 18 years old. The average weight of the players also saw a moderate increase from 53.5 kg to 56.3 kg. Generally, there is only a moderate increase of physical proportions in Japanese female players once past the age of 15 years old. When physical proportions are compared to general Japanese women of the same age, the player height is approximately 2.5 cm taller, and weight is approximately 2 to 3 kg heavier. When comparing the figure of the subjects and the players representing Japan in the under-18 team who participated in the 6th Asian Women's Youth Handball Championship, the overall height of the subjects was approximately 2.5cm lower.

Table 1 *Physical performances of female junior handball players*

Age	SLJ (cm)	STSJ (cm)	Side Steps	SHT (m)	SLR (°)	20m SR
16 years	200.8±15.2	570.9±40.2	54.5±3.6	16.2±2.3	93.2±15.3	91.2±12.9
17 years	201.9±15.3	558.4±46.3	55.5±2.1	17.4±2.0	94.8±16.9	96.7±10.0
18 years	204.8±15.6	590.6±39.7	55.7±3.6	18.2±2.3	92.4±12.6	95.4±7.4

Age	MBT (m)	Hand Grip (kg)	Back Strength (kg)	Sit Ups	30m SS (sec.)	30m CDS (sec.)	30mCDS /30mSS
16 years	7.1±1.2	30.7±4.7	80.1±13.2	32.9±3.7	5.11±0.22	7.88±0.34	1.54
17 years	7.5±1.2	32.3±5.6	87.3±17.1	31.5±3.3	5.08±0.27	7.86±0.39	1.55
18 years	7.9±1.3	35.3±4.7	85.8±16.7	33.4±3.4	5.04±0.33	7.85±0.34	1.56

Table 2 *Physical performances of NTS U-18 female handball players (n=240)*

Age	SLJ (cm)	STSJ (cm)	Side Steps	SHT (m)	SLR (°)	20m SR
NTS women U-18	207.70	606.90	60.70	20.11		87.30

Age	MBT (m)	Hand Grip (kg)	Back Strength (kg)	Sit Ups	30m SS (sec.)	30m CDS (sec.)	30mCDS /30mSS
NTS women U-18	8.30	34.00		32.80	5.14	7.37	1.43

The results of the physical measurements are shown in table 1. When compared with the athletic data of the U-18 top national players (table 2) who participated in the National Training System Center Training 2007-2014 (NTS) held by the Japan Handball Association, although the sprinting ability, cardiovascular ability and muscular endurance of the research subjects surpassed that of the national players, their jumping ability, agility and power was inferior. It is also of great interest that when compared to the NTS players, although the subjects were overall faster, it is shown that the NTS players were significantly faster in regards to the 3 (130 degree) changes of direction within the 30m sprint. In regards to this difference in the speed at which the players change direction, it is not clear whether the problem is physical, technical or cognitive.

Our comparison of the players who continued physical training for 2 years indicated that the players aged 16 to 17 years showed significant increases in height, SHT, MBT, Hand Grip, Back Strength, and 20 m SR. However, the players aged 17 to 18 years showed significant increases in height, but not physical strength. These results indicate that players aged 16 to 17 years showed large improvements in physical strength, whereas those aged 17 to 18 years showed more gradual increases in physical strength. Our investigation of the players who continued physical training for 3 years indicated that they experienced significant improvements in muscle strength, intermittent running ability, and aerobic capacity. In particular¸ throwing ability showed a strong correlation to physical power as age increased. This is likely due to the improvements in ball-throwing ability that resulted from the increased hand grip and core muscular strengths (Figure 1).

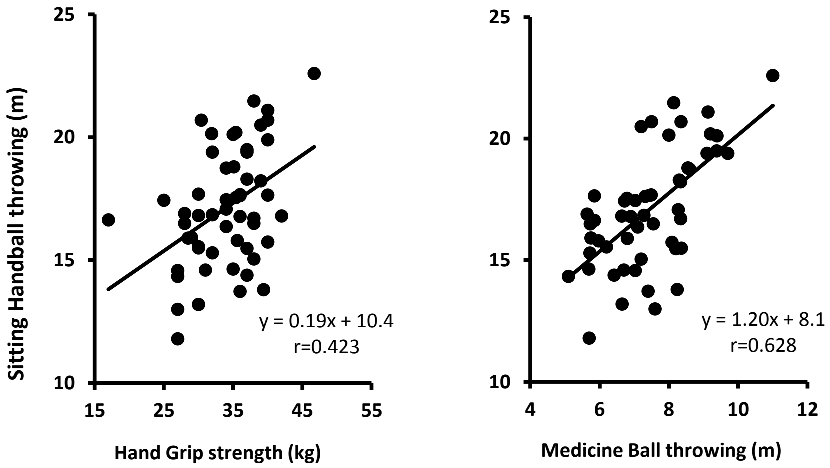

Figure 1 *Relationship between sitting handball throwing and physical strength and power*

Christian R. Et al (2015) carried out medicine ball training (1 to 2kg) 3 times a week over a period of 6 weeks on female handball players with an average age of 21, reporting an enhancement in muscular strength around the shoulder, as well as the improvement of ball speed. This research had utilised a 3kg medicine ball, carrying out overhead throws and overhead backward throw exercises 2 to 3 times a week. As shown in relevant result of improvement ratios of physical strength, it can be surmised that such training is connected to the enhancement in the groups of muscles surrounding the shoulder, as well as an increase in the muscles within the core of the body. On the other hand, the carrying out of long-term training saw little to no improvement. Monsef C. (2012) carried out jump and sprint training on male handball players over a period of 3 months, reporting on less than a 3% increase in jump and sprinting ability. However, in this study the rate of improvement in sprinting ability, speed of changing direction, jumping ability and agility was exceedingly small (table 3). There may be a need to reexamine sprint and jump training programs in regards to female players.

Table 3 *Rate of improvement after physical training*

More than 18%	**MBT, Back Strength**
15%-18%	**SHT**
12-15%	**20 m SR, Hand Grip**
9%-12%	---------
6-9%	**SLR**
3%-6%	---------
Less than 3%	**Height, Weight, SLJ, STLJ, Sit ups, Side steps**
No improvement	**30 m SS, 30m CDS**

CONCLUSION

It can be observed that carrying out long-term handball training on Japan's female junior players results in the improvement of muscle and muscular power as well as throwing ability, and the improvement of endurance. On the other hand, the improvement of jump and sprinting ability could not be observed.

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PHYSICAL FACTORS RELATED TO CHANGE-OF-DIRECTION SPRINTING AMONG JAPANESE HANDBALL PLAYERS: THE RELATIONSHIP BETWEEN STRAIGHT SPRINTING, CHANGE-OF-DIRECTION SPRINTING, AND JUMPING POWER

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SUMMARY

The objectives of this study were to elucidate the physical characteristics of the figure-eight change-of-direction test conducted by the Japan Handball Association and identify the relationship between straight sprinting, change-of-direction sprinting, and jumping power. The results of this study indicate the possibility that because deceleration from a high speed, turning, and reacceleration are important to 30m CDS, leg muscle power plays a major role in this task. By contrast, because speed does not increase during the straight sprint portions of approximately 17m CDS, turning skill, posture adjustment, and cognitive elements play a major role compared with leg muscle power, which is related to deceleration and reacceleration.

Keywords: handball, physical training, change of direction sprint, agility test

INTRODUCTION

In handball and other ball games, in addition to instantaneous and endurance running skills, change-of-direction skills that allow a player to instantaneously change running direction in response to the ball and the positions of other players are also required. Experience has shown that in handball, general running skills such as "speeding up," "slowing down," and "changing direction" influence the competitiveness of individual players, and are among the important factors that sometimes influence which team wins the game. Many scientific studies have been conducted on training methods such as sprint training and plyometrics that are designed to improve running and jumping skills (Buchheit M. et al. 2010, Cherif M. et al. 2012), and several studies of the effect of agility training have been conducted by Young et al. Some of these studies have elucidated factors such as physical strength (sprinting power and muscle strength), perception, and technique that are used when players quickly change direction (Young et al. 2002). Nevertheless, since it is extremely difficult to individually identify and study the factors (physical strength, perception, technique, etc.) that contribute to quick direction changing, this issue has rarely been investigated.

Tanaka et al. proposed a figure-eight course (6 m–9 m–6 m–9 m: total of 30 m) for assessing the change-of-direction skill of Japanese Junior Handball players (Tanaka M. 2009). The Japanese National Training System adopted this agility test in 2009 and is currently still using it. This change-of-direction skill test calculates the relative relationship of a 30m straight sprint and a 30m change of direction sprint, which allows researchers to obtain the rate of delay with the addition of three sharp direction changes. Previously, we attempted to assess individual change-of-direction ability based on this rate of delay (Moriguchi T. 2013). The present study investigated the contribution made by the factors: physical strength and turning technique by testing runners on three types of courses with the same change-of-direction angles but differing running distances in order to elucidate the contributions of physical strength and technique when quickly changing direction.

METHOD

Subjects:

Nineteen male college handball players in the Kyushu Region Student Handball Top League underwent a series of field tests from October to November 2014. The participants' mean age, height, weight, and years of handball experience, were 20.4±1.38 y, 173.5±5.37 cm, 65.3±4.56 kg, and 6.5±1.43 y, respectively (presented as mean ± standard deviation [SD]). Written explanations of the purpose, measurement items, and measurement methods were distributed to all participants, and their consents were obtained. Consents were also obtained for the use of the individual measurement data of all participants.

Physical measurements:

The following four measurements were obtained: straight sprint (SS), change-of-direction sprint (CDS), counter-movement jump (CMJ), and squat jump (SJ). The running capacity test consisted of the following tests at three different distances: SS and CDS of 30 m (L) each, 22.5 m (M = 75%, 30 m) each, and 16.875 m (S = 75%, 22.5 m). The CDS tests were started on the right, and all turn angles were approximately 130° (Figure 1). "DIGI-TIMER" phototube sensors were used to perform measurements in all running tests. The change-of-direction ability index (CDS index), calculated as change-of-direction value divided by the straight sprint value, was used for the analysis.

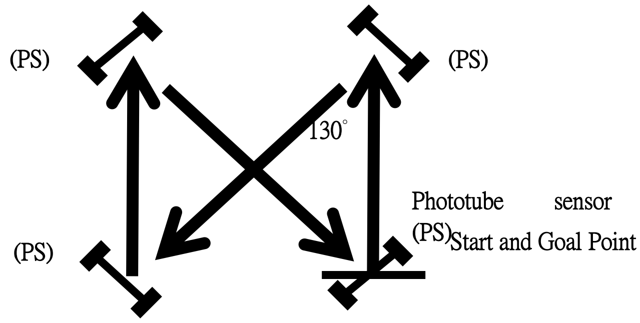

Figure 1 *Changes of Direction Sprint test (L; 30m, M; 22.5m, S; 16.875m)*
All turn angles were approximately 130°.

Statistical analysis:

All data obtained are shown as mean ± SD. The Pearson product-moment correlation coefficient was used to calculate the correlation between the results of the straight sprint, change-of-direction sprint, change-of-direction ability index, and jumping skill test. We used one-way analysis of variance to compare change-of-direction sprints by distance and performed multiple comparison analysis. Statistical significance of the test results was set at 5%.

RESULT and DISCUSSION

The mean speeds in straight sprint (SS; table 1) were 26.4 $\pm$ 0.9 km/h for the 30-m SS (L-SS), 25.1 $\pm$ 1.0 km/h for the 22.5-m SS (M-SS), and 23.9 $\pm$ 1.0 km/h for the 16.875-m SS (S-SS). These values indicate that as the distance increased, the mean speed significantly increased ($p < 0.01$). The mean speeds during change-of-direction sprint (CDS; table 2) were 14.8 $\pm$ 0.6 km/h for the 30m CDS (L-CDS), 13.6 $\pm$ 1.1 km/h for the 22.5m CDS (M-CDS), and 12.5 $\pm$ 0.7 km/h for the 16.875m CDS (S-CDS). These values indicate that as the distance increased, the mean speed significantly increased ($p < 0.01$). The CDS indexes were as follows: L-CDS, 1.805; M-CDS, 1.885; and S-CDS, 1.935.

Table 1 *Result of Straight Sprint tests (SS)*

	Time (sec.)	Average Speed (km/h)
L-SS	**4.09±0.14**	**26.39±0.91**
M-SS	**3.23±0.14**	**25.12±1.06**
S-SS	**2.55±0.11**	**23.90±1.01**

Table 2 *Result of Changes of Direction Sprint tests (CDS)*

	Time of one side (sec.)				Total Time (sec.)	Average Speed (km/h)	CDS index
L-CDS	**(6m) 1.33**	**(9m) 2.26**	**(6m) 1.77**	**(9m) 2.03**	**7.39±0.33**	**14.78±0.61**	**1.81**
M-CDS	**(4.5m) 1.11**	**(6.75m) 1.79**	**(4.5m) 1.54**	**(6.75m) 1.65**	**6.08±0.43**	**13.59±1.11**	**1.88**
S-CDS	**(3.375m) 0.93**	**(5.062m) 1.48**	**(3.375m) 1.09**	**(5.062m) 1.41**	**4.92±0.29**	**12.50±0.67**	**1.94**

The results of our comparison of the speeds at different distances in the SS tests, CDS tests and CDS indexes indicated significant differences between the average speeds of the three distance tests, with L-CDS being the fastest, followed by M-CDS and S-CDS in descending order. Meanwhile, the results of the one-way analysis of variance showed significant differences in CDS index between the different distances in the CDS test. A multiple comparison of the tests indicated a significant difference between L-CDS and S-CDS. In the comparison with the 180% delay in the L-CDS straight sprint ratio, a 193% delay was observed in the S-CDS straight sprint ratio. Our investigation of the change-of-direction characteristics for the three different distance patterns indicated that for L-CDS, greater effort was required to reaccelerate when turning, despite the fact that the speed tended to increase during the straight sprint portions. Meanwhile, for S-CDS, although running speed did not tend to increase during the straight sprint portions, less effort was required when turning.

Table 2 *Relationship between Straight Sprints and Changes of Direction Sprints.*
The Pearson product-moment correlation coefficient was used to calculate the correlation between the results of SS, CDS

	L-SS	M-SS	S-SS	L-CDS	M-CDS	S-CDS
L-SS		**0.875**	**0.783**	**0.489**	**0.516**	**0.199**
M-SS	**-**		**0.831**	**0.317**	**0.314**	**0.066**
S-DD	**-**	**-**		**0.198**	**0.357**	**0.147**
L-CDS	**-**	**-**	**-**		**0.658**	**0.594**
M-CDS	**-**	**-**	**-**	**-**		**0.674**
S-CDS	**-**	**-**	**-**	**-**	**-**	

These results could be predicted by calculating the correlation coefficient between the running speeds for the SS and CDS. Although the speeds for L-SS and L-CDS significantly correlated, the correlation between the speeds for L-SS and S-CDS was extremely low. This indicates that even individuals with a high degree of sprint ability may not necessarily be quick in changing direction on short courses.

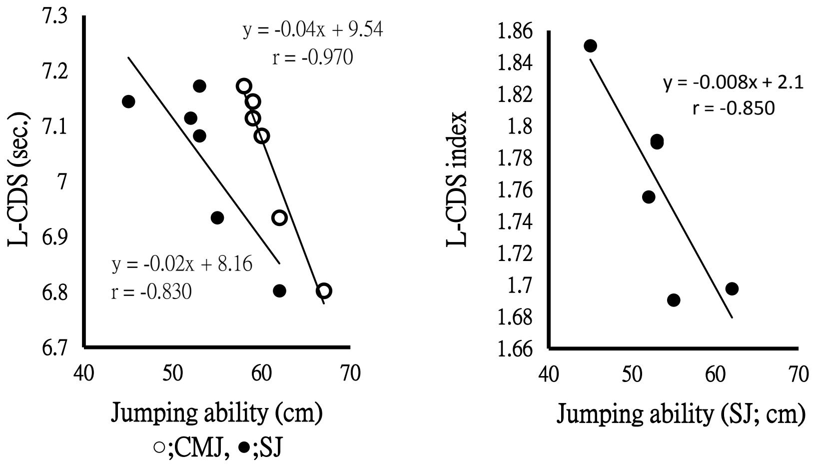

Figure 2 *Relationship between jumping ability and L-CDS performance of the best 6 players.*

Iwatake et al. (2009) confirmed the correlation between vertical jumping ability and sprint performance. In the present study, although moderately correlated with SS, jumping ability in squat jump (SJ) or countermovement jump (CMJ; r = 0.490-0.530) did not correlate with CDS. Based on this result, we conjecture that many factors are involved in CDS, including leg power.

Of the 6 who did the best in L-CDS, the subjects with good records for CMJ and SJ showed a high correlation with having good records for L-CDS and change-of-direction index (figure 2). However, no such correlation was observed in the 6 who did poorly in L-CDS. We hypothesized that persons who perform well in CDS, which includes long straight runs, have both high sprint power and leg power. However, we found that jumping ability did not significantly correlate with M-CDS and S-CDS performances (figure 3). As a result of the slight change in speed during turns on the M-CDS and S-CDS courses with short straight runs, lower leg power plays a small role and only slightly correlated with CMJ and SJ. In other words, we believe that in short-distance CDS, factors other than sprint power and leg power, such as perception and technique, play a role.

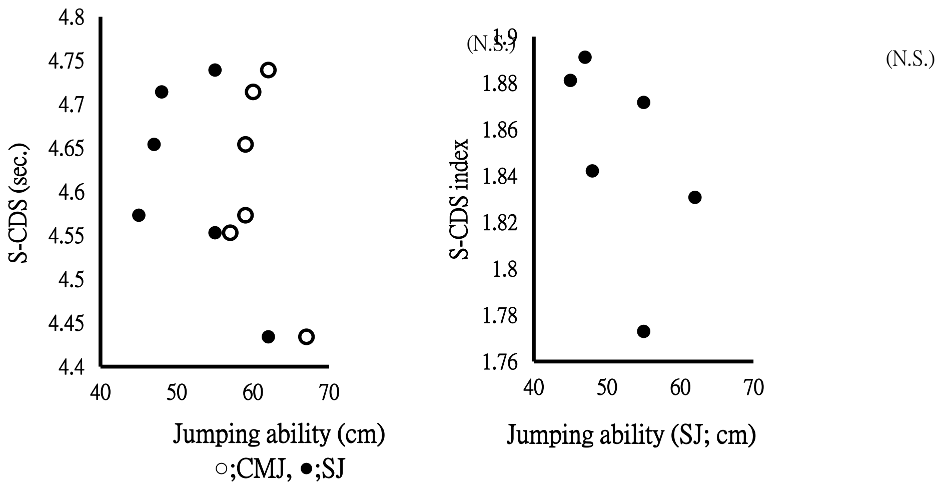

Figure 3 *Relationship between jumping ability and S-CDS performance of the best 6 players.*

The results of this study indicate the possibility that because deceleration from a high speed, turning, and reacceleration are important to L-CDS, leg muscle power plays the major role in this task. By contrast, because speed does not increase during the straight sprint portions of S-CDS, turning skill, posture adjustment, and cognitive elements play the major role compared with leg muscle power, which is related to deceleration and reacceleration. Inertia in the sprinting direction is generated when direction is changed during sprinting. Considering that the sprinting speed during direction changes in long-distance CDS was significantly higher than that in short-distance CDS, we believe that a large amount of inertia is generated during direction changes. Previous studies reported that the difference in skill level is reflected in the time required for each movement because movement becomes more difficult when the motion velocity is high and the angle of direction change is large (Imamura K. 2006). Based on this, differences in the speed on the straight runs may be a factor that causes delayed turning. Moreover, Kimura et al. (2010) reported that one of the important factors that affects direction change is technique-related and allows the runner to stabilize the torso in order to adjust the center of gravity. This suggests that when entering turns at low speed on courses with short straight runs, a technique disparity may occur between these changes in direction and the difficult changes in direction on sharp turns of approximately 130°.

CONCLUSION
The results of this study indicate that the influence of the leg power required to decelerate and reaccelerate, and the techniques used and center of gravity adjustment that allow the runner to turn quickly when engaging in CDS of different lengths may be separately assessed, suggesting that simple tests of runner performance may be conducted in the field.

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THE EFFECTS OF 6-WEEK CREEPING EXERCISE PROGRAM ON REPETITIVE STRENGTH IN YOUNG HANDBALL PLAYERS

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Summary
The purpose of this study was to determine the effects of a specifically designed 6-week biweekly creeping workout program on repetitive strength in young handball players. The study included 28 handball players aged between 7 and 11 years. They were randomly divided into two sub-groups, the experimental group and the control group. Their initial and final state of repetitive upper-body (arm and shoulder girdle), lower limbs and core strength was measured with six motor tests. The experimental group significantly improved their result in all tests.

Keywords: young handball players, creeping, repetitive strength.

Introduction
The result in Handball match depends on many factors, among which, already in younger age groups, strength is very important. Strength is manifested in almost all the elements of handball game: in jumping, sprinting, landing, when performing passes, in various shots, changes the direction of movement and at stopping and holding of an opponent (Sibila, 2004). Choosing the appropriate training content is, when planning the development of strength in the senior age category, fairly well defined, as there is a wide choice of methods and means which favourably affect the progress of the various manifestations of strength in adult handball players.

It is, of course, necessary to consider certain rules concerning appropriate quantity and exercise intensity. But it's important to start with a coherent and efficient development of strength in handball players much earlier. In the past it was considered that strength training for younger age groups does not produce the desired results and can even be dangerous, and cause disturbances in growth (Pierce, Byrd & Stone, 1999). Recent research suggests that it was a wrong conviction. But models of exercise for adults should not be transfer to children and adolescents training, but they should be adapted to the developmental stage of the child. Among others, strength training should be interesting and varied to maintain the motivation of children to exercise thus to avoid decreasing in intensity.

Therefore, the approach to strength training in young handball players must be undertaken in a planned and thoughtful manner. It's necessary to consider biological order in growing up. Natural forms of movement could be considered as one of the most suitable means for developing strength in youth age categories, since these phylogenetically developed movements are appearing in everyday life, and are therefore familiar to children (Pori, 2007). In particular, various forms of creeping should be taken into account, while they affect the muscles of legs, arms, shoulder girdle and torso, i.e. body segments, which are very exposed in handball.

Creeping is human locomotion in a support position (front or back support position) where weight is on hands and feet, torso is raised-up from floor. Locomotion is executed with a help of arms and legs. In comparison with crawling, in creeping there is less friction due to the torso raised from the ground. But they can also be energetically demanding as crawling, because the movement can be considerably faster. Loads that reach around 40% of maximum muscle strain may be elicited already with the basic forms of creeping. But if more advanced versions are used, load may also reach 90% of maximum muscle strain (Pistotnik, Pinter & Dolenec, 2002). In the training creeping and crawling may be included as a separate mean or as a part of elementary games. On the basis of the above mentioned facts the purpose of this study was to determine the effects of a specifically designed 6-week biweekly creeping workout program on static strength in young handball players.

Methods

Sample

The study included 28 handball players aged between 7 and 11 years. They were randomly divided into two sub-groups, the experimental group and the control group -14 players in each group. The average age of the control group was 9,2 ± 1,2 and the average age of the experimental group was,9,56 ± 1,0 year.

Procedure

Both groups performed the initial and final testing. The experimental group performed a 6-week, twice a week creeping workout program between the initial and final testing (Table 1). Difficulty of exercise is escalated every week with concerning amount and the mode of a creeping. Rest between the series was 1,5 minute and rest between exercises 2,5 minute.

Table 1: *Content of 6-week biweekly workout program of creeping*

Week	Nr. of units	Type of creeping	Nr. of series	Distance (m)
1	2	A	3	10
		B	2	10
2	2	C	3	10
		D	3	10
3	2	E	2	10
		B	3	10
4	2	F	2	10
		E	3	10
5	2	G	3	12
		B	3	10
6	2	F	3	12
		G	3	12

Note. A - Front Support Position, moving forward (“walk on all fours”); B - Back Support Position – moving backwards (“Crab walk”); C - Front Support Position, moving backwards; D - Back Support Position – moving forward; E - Front Support Position, moving forward by dragging feet behind (“Seal walk”); F - Back Support Position, moving backwards by dragging feet behind (“Seal walk”); G - Front Support Position, with the raised legs and partner supporting the thigh (“the wheelbarrow”).

Variables

Initial and final state of repetitive arm, shoulder girdle, leg and torso strength was measured with six motor tests.

Table2: *Sample of variables*

Test	Measured capacity	Measuring unit
pulling on the bench	repetitive arm and shoulder strength	seconds
pushing on the bench	repetitive arm and shoulder strength	seconds
pull-ups test	repetitive arm and shoulder strength	Nr. of repetitions
push-ups test	repetitive arm and shoulder strength	Nr. of repetitions
sit-ups test	repetitive torso strength	Nr. of repetitions
squat test	repetitive leg strength	Nr. of repetitions

In Table 2 all variables are presented. Four test are dedicated for measuring the repetitive arm and shoulder strength, one test for repetitive torso strength and one for repetitive leg strength. All tests were summarized by various authors and are described in the literature (Mackenzie, 2005; Fratina, 2011).

Data analysis

The data were analysed using the statistical package SPSS 20.0. Basic parameters of the distribution of variables were calculated (mean, standard deviation, minimum and maximum values). Changes between initial and final measurements were determined by Student's paired t-test. A probability level of 0.01 or less and 0.05 or less was taken to indicate significance.

Results

Table 3 presents the basic statistical characteristics of all measured parameters obtained at the initial and final measurement for experimental group. The table shows average values, standard deviations, minimum and maximum values and significance of Student's paired t-test.

Table 3*: Basic statistical characteristics of all parameters on initial and final measurements and significance of Student's paired t-test for experimental group*

	Initial measurements				Final measurements				
Parameter	$\bar{x}$	**s**	**min**	**max**	$\bar{x}$	**s**	**min**	**max**	**P**
pulling on the bench	12,0	2,2	8,3	15,8	10,4	1,9	7,6	13,0	<0.01
pushing on the bench	19,8	6,1	11,4	30,0	17,2	4,0	12,0	26,1	<0.05
pull-ups test	9,0	4,3	2,0	15,0	10,7	4,4	2,0	18,0	<0.01
push-ups test	14,3	5,3	4,0	20,0	16,6	6,0	5,0	24,0	<0.01
sit-ups test	31,0	6,4	16,0	41,0	33,6	6,9	19,0	46,0	<0.01
squat test	37,5	9,2	17	55	39,1	9,7	21	60	<0.05

Note. $\bar{x}$ - Average values; s - standard deviations; min – minimum values; max - maximum value; P – significance of Student's paired t-test.

Table 4: *Basic statistical characteristics of all parameters on initial and final measurements and significance of Student's paired t-test for control group*

	Initial measurements				Final measurements				
Parameter	$\bar{x}$	**s**	**min**	**max**	$\bar{x}$	**s**	**min**	**max**	**P**
pulling on the bench	12,5	2,8	6,7	16,0	12,6	2,4	7,9	17,2	>0.05
pushing on the bench	21,3	6,5	11,4	36,0	21,5	5,9	12,1	33,2	>0.05
pull-up test	6,9	4,2	1	13	7,0	4,0	2	14	>0.05
push-up test	12,0	6,1	3	23	12,2	6,3	4	24	>0.05
sit-up test	27,5	7,0	18,0	38,0	27,2	6,1	17,0	37,0	>0.05
squat test	31,4	9,7	17	55	30,8	8,8	18	52	>0.05

Note. $\bar{x}$ - Average values; s - standard deviations; min – minimum values; max - maximum value; P – significance of Student's paired t-test.

Table 4 presents the basic statistical characteristics of all measured parameters obtained at the initial and final measurement for control group. The table shows average values, standard deviations, minimum and maximum values and significance of Student's paired t-test.

Discussion and Conclusions

Results of our study indicate that experimental group significantly improved their results in all six tests. If we take into consideration percentage of improvement the highest average improvement was recorded at the pull-up test – 24.5% ($p<0.01$), followed by the push-up test – 17.8% ($p<0.01$), sit-up test – 8.8% ($p<0.01$) and by the squat test with 4.9% ($p<0.05$) improvement. On the contrary no statistically significant differences were observed in control group. We may conclude from our study that supplementary 6-week creeping workout program in young handball player's increases static upper-body and core muscles strength. Probably we should we say that progress in strength was mainly attributed to neurological adaptations, which are most pronounced in the early stages of training, while in this period optimization of intra-muscular coordination by agonists, synergists and stabilizers occur. Folland and Williams (2007, as cited in Behm et al., 2008) speculated that the contribution of neurological adaptation depends on the level of preparedness of an individual prior to start with a workout. This shows that in children who are less prepared/experienced than adults, this contribution is larger and faster. Falk and Tenenbaum (1996) report that strength by pre-pubertal children increased for 13-30% during a special designed strength program which lasted 8-20 weeks.

In many other researches it was proven that children may improve their strength during a well planed training. Improvement of strength for 30-40 % was recorded by children who participated in 8-12 weeks strength training program. Even 6-years old children benefit from strength training. In pre-puberty period there is no evidence about differences in strength between boys and girls (Earle & Baechle, 2004). By our entities the improvement were slightly lower, but it was probably due to relatively short duration of the experiment. Based on the results we can speculate that larger improvement in strength could be achieved if training duration would increase. That's why creeping was long ago proposed as one of the most appropriate training mean to enhance strength by handball players in age from 7 to 10 years (Pori, Luzar & Šibila, 2010). The contemporary lifestyle of children with a lot of seating and limited possibilities for spontaneous play and carrying out other motor activities (eg. climbing on the trees) has led to a reduction of a strength in children. It's very important, that already in children, coaches dedicate enough attention on development of this motor skill. By doing this some principles should be followed: children must be supervised and corrected in exercising in the way that exercises are performed technically correct; activities must be designed in such a way that all children are active; in exercising it is necessary to avoid monotony (Earle in Baechle, 2004). Furthermore, for optimal effect of exercising strength in children it's necessary to consider some other rules: it is necessary to ensure a safe and enjoyable training environment; an adequate warm-up is important before starting with strength exercises; recommended are 2-3 training units per week; strength training should not be performed in consecutive days; various parts of the body should be involved in exercising (whole body); it is necessary to take into account the gradualness of motor tasks – load should increases gradually with increment of strength (Faigenbaum et al., 1996). Creeping can be also largely utilized in the development of strength in the older age categories, while introduce other, particularly more intensive means of strength training (Pori, Luzar & Šibila, 2010).

References

Behm, G. D., Faigenbaum, A. D., Falk, B. Klentrou, P. (2008). Canadian Society for Exercise Physiology position paper: resistance training in children and adolescents. *Appl. Physio.l Nutr. Metab. 33,* 547-561.

Earle, R. W. &, Baechle, T. R. (2004). *NSCA's essentials of personal training*. Champaign, IL: Human Kinetics.

Faigenbaum, A.D., Kraemer, W. J., Cahill, B., Chandler, J., Dziados, J., Elfrink, L. D., … Roberts, S. (1996). Youth resistance training: NSCA Position Statement Paper and Literature Review. *Strength and Conditioning, 18*(6), 62-75.

Falk, B., & Tenenbaum, G. (1996). The effectiveness of resistance training in children: A metaanalysis. *Sports Medicine*, 176-186.

Fratina, R. (2011). *Vpliv vadbe lazenja na moč rok* [Effects of creeping exercises on the strength of arms. In Slovenian.]. (Bachelor's thesis). Ljubljana: Fakulteta za šport

Mackenzie, B. (2005). *101 Performance Evaluation Tests*. London: Eletric World.

Pierce, K. C., Byrd, R., & Stone, M. H. (1999). Youth weightlifting – is it safe? *Weightlifting USA, 17*(4), 5.

Pistotnik, B., Pinter, S. & Dolenec, M. (2002). *Gibalna abeceda*. [Physical exercise alphabet. In Slovenian.]. Ljubljana: Fakulteta za šport.

Pori, P. (2007). Naravne oblike gibanja kot sredstvo razvoja moči mladih rokometašev (1. del – plazenja in lazenja). [Natural forms of locomotion as a means of developing strength in young handball players (1. Part – creeping and crawling). In Slovenian.]. *Trener rokomet, 14*(1), 17-23.

Pori, P., Luzar, K., & Šibila, M. (2010) Uvajanje otrok in mladostnikov v vadbo z utežmi. [Introducing children and adolescents in Weight Training. In Slovenian.]. *Trener rokomet, 17*(2), 25-30.

Šibila, M. (2004). Rokomet: izbrana poglavja. [Handball: Selected Chapters. 2nd revised ed. . In Slovenian.]. Ljubljana: Univerza v Ljubljani, Fakulteta za šport.

RELATIONSHIP BETWEEN ANTHROPOMETRIC PARAMETERS AND THROWING VELOCITY IN SLOVENIAN JUNIOR ELITE HANDBALL PLAYERS

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Summary

The purpose of this study was to determine the relationship between anthropometric parameters and throwing velocity in Slovenian junior and youth elite handball players. The study included 91 handball players aged between 17 and 21 years (17.89±1.89 years). Players executed two different handball shoots – standing shoot and jump shot with three steps approach (run-up). Correlations were established by Pearson correlation coefficient. We may conclude that several anthropometric parameters are in a positive relationship with the throwing velocity in both types of handball shot.

Keywords: male junior handball, throwing velocity, anthropometric.

Introduction

Throwing velocity of the ball is an important skill in handball and a very important aspect for success because the faster the ball is thrown at the goal, the less time defenders and goalkeeper have to save the shot (Vila et al., 2012). To succeed in an attempt to score a goal, a team handball player must maximize the precision of the throw as well as ball release speed. This is especially true when throwing from a distance of more than 8 m from the goal (backcourt position). It is well known that team-handball players use different throwing techniques based on their playing position and it is dictated by the movements of the defensive players (Wagner et al., 2012). In competition, 73-75% of all throws during the game constitute jump throws, followed by the standing throw with run-up (14-18%), penalty throw (6-9%), diving throw (2-4%) and direct free throw (0-1%) (Wagner et al., 2008). If we isolate the final throw and ignore outer factors that can not be influenced by the player himself during a game, it can be stated that the outcome of the shot, besides the precision, dominantly depends on ball speed (Rogulj et al., 2007), that is, on all the anthropological features of the player that determine final ball movement speed in shot (Srhoj et al., 2012). Recent studies analyzing the throwing movement in team-handball suggest that different throwing techniques result in different ball velocities (Wagner et al., 2011). Bayios and Boudolos (1998) described differences in ball velocity and the throwing accuracy of Greek elite team-handball players revealing that greatest ball velocity was achieved in the standing throw with run-up (26.3 ± 3.2 $m \cdot s^{-1}$) rather than the standing throw without run-up (23.5 ± 2.2 $m \cdot s^{-1}$) and jump throw (22.7 ± 2 $m \cdot s^{-1}$).

Over a long time of research of the handball shot the key characteristics were isolated by most authors studying the bio-mechanical characteristics:

- The correct order of recruitment of the individual parts of the body is important, allowing the development of maximal velocity and control of these parts – this order is from the proximal (central) parts to the distal (distant) parts of the body.
- The most proximal part begins the action, it is then followed by the next, and so on till the most distal part – the wrist or the palm.
- The velocity of movement of the smaller and lighter parts of the body with lesser inertia is added to the velocity of the bigger ones, achieving the greatest possible velocity at the end part of the kinematic chain (each proximal part offers support for the next, more distal part).

- The increase of angular velocity of the individual segment of the kinematic chain is connected to the stoppage of the proximal part (the angular velocity of the elbow is greater after stopping the movement of the shoulder, of the wrist after stopping the elbow (Šibila et al., 2003).

Usually technique of jump shot anticipates take-off with the leg which is opposite the throwing hand (right handers use the left leg for take-off). Very similar is technique in standing shot with run-up. In javelin throwing, Whiting et al. (1991) (as cited in Wagner et al., 2011) suggested that the lead leg braces is also opposite to the throwing arm thus allows the pelvis, trunk and throwing arm to accelerate over the braced leg and aid in a transfer of momentum through the pelvis and trunk to the throwing arm. In this case the player gains the correct natural co-ordination, which allows successful – forceful and accurate - shot towards the goal (Šibila et al., 2003). The aim of this study is to determine the relationship between anthropometric parameters and throwing velocity achieved in two shot techniques in Slovenian junior and youth elite handball players, thus providing data that can be used as guidelines in everyday practice.

Methods

Sample

The subjects were 91 Slovenian young elite handball players which participate in regular testing of Slovenian junior national teams – they belong to three different generations (born 1994/95, 1996/97 and 1998/99). At the time of measurement, the study subjects were 17.89±1.89 years old on average. Their average body height was 186.9±6.63 cm and body mass 84.4±11.64 kg.

Variables

A standardised anthropometric protocol was used to assess the subjects' morphological characteristics (Bravničar, 1987). The measurements included 9 different anthropometric measures covering three morphological dimensions: longitudinal measures, diameters and circumferences. Ball release velocity ($m \cdot s^{-1}$) was assessed in two different handball shoots. All measurements were conducted by the same people, using the same measurement technology.

Table1: *Sample of variables*

Test	Measured capacity	Measuring unit
Jump shoot	Shoot ability	$m \cdot s^{-1}$
Ground shoot	Shoot ability	$m \cdot s^{-1}$
Body height	Longitudinal dimension	cm
Body mass	Body volume	kg
Circumference of upper arm (relaxed)	Body volume (circumferences)	cm
Circumference of forearm	Body volume (circumferences)	cm
Circumference of calf	Body volume (circumferences)	cm
Biacromial diameter	Transversal dimension (diameters)	cm
Wrist diameter	Transversal dimension (diameters)	cm
Humerus diameter	Transversal dimension (diameters)	cm
Femur diameter	Transversal dimension (diameters)	cm

Procedure

Ball throwing velocity was evaluated on an indoor handball court. Participants performed two different techniques: jump shoot and standing shoot with run-up (three shots each). First they chose a starting position for approach in the middle of the playing court. Their approach (run-up) consisted of two parts. First they did three steps, bounce the ball and after that performed three steps of approach. Last step of approach should be performed in an area, which was marked on the free-throw line. Shoots were performed with the maximal effort towards the goal. Participants were instructed to throw the ball onto a target at 9 m distance (in a handball goal). Ball speed for the throws was measured with a calibrated radar gun (Emg companies, inc., ZDA, model 52000), placed behind the goal post. Three trials were performed for each experimental situation, and the best throw (the shoot where the highest velocity was achieved) for each type of shoot was used for analysis. Ball dimension 3 according to IHF rules was used for all shoots.

Data analysis

The data were analysed using the statistical package SPSS 20.0. Basic parameters of the distribution of variables were calculated (mean, standard deviation, minimum and maximum values, kurtosis, skewness and Kolmogorov-Smirnov test of normality). Pearson Correlation Coefficient was used to test the degree of correlation among the variables. A probability level of 0.01 or less and 0.05 or less was taken to indicate significance.

Results

Table 2 presents the basic statistical characteristics of both shoots and all selected morphological parameters. The table shows average values, standard deviations, minimum and maximum values, kurtosis, skewness and significance of the Kolmogorov-Smirnov test.

Table 2: *Basic statistical characteristics of all parameters*

Parameter	$\bar{x}$	S	Min	Max	kurt	skew	pK-S
Age	17.89	1.89	15.0	21.0			
Jump shoot	24,4	1,72	21,31	28,8	,096	-,495	,200
Ground shoot	26,71	2,01	22,22	30,75	-,706	,005	,200
Body height	186.9	4.68	170.5	202.0	,064	,052	,200
Body mass	84.4	11.64	61.4	116.1	,208	,514	,200
Circumference of upper arm (relaxed)	31,87	2,74	24,3	38,5	-,245	,133	,200
Circumference of forearm	29,1	1,83	24,0	35,0	,586	,500	,200
Circumference of calf	40,55	2,41	34,8	46,0	-,209	-,064	,054
Biacromial diameter	42,42	2,13	37,7	49,9	,795	,500	,200
Wrist diameter	6,03	,34	5,3	6,9	-,265	-,068	,011
Humerus diameter	7,45	,43	6,0	8,8	,637	1,245	,027
Femur diameter	10,28	,50	9,0	11,5	-,075	,122	,200

Note. $\bar{x}$ - average values; s - standard deviations; min – minimum values; max - maximum values; kurt – kurtosis; skew – skewness; pK-S – significance of the Kolmogorov-Smirnov test.

The data reveal that all measured parameters, with exception of wrist and humerus diameter, are normally distributed.

Table 3 show the results of Pearson Correlation coefficients based on which we established whether there were any statistically significant relationships between anthropometric parameters and throwing velocity. In the table we placed also the coefficients that show the correlation between anthropometric variables themselves.

Table 3: *Values of Pearson Correlation coefficients among all variables*

	SS	JS	BH	BM	CUA	CFA	CC	BAD	WD	HD	FD
SS	1.000										
JS	,891**	1.000									
BH	,468**	,509**	1.000								
BM	,385**	,439**	,667**	1.000							
CUA	,384**	,453**	,435**	,866**	1.000						
CFA	,405**	,482**	,519**	,838**	,850**	1.000					
CC	,273**	,366**	,546**	,837**	,759**	,726**	1.000				
BAD	,439**	,508**	,538**	,600**	,561**	,532**	,519**	1.000			
WD	,397**	,400**	,624**	,523**	,416**	,555**	,385**	,505**	1.000		
HD	,252*	,298**	,640**	,643**	,515**	,622**	,602**	,417**	,514**	1.000	
FD	,343**	,420**	,684**	,684**	,499**	,587**	,628**	,484**	,585**	,657**	1.000

Note. SS – standing shoot; JS – jump shoot; BH – body height; BM – body mass; CUA - Circumference of upper arm (relaxed); CFA - Circumference of forearm; CC - Circumference of calf; BAD – Bi-acromial diameter ; WD - Wrist diameter; HD - Humerus diameter; FD - Femur diameter.
*p<0.05, **p<0.01.

Discussion and Conclusions

If we compare the throwing velocity when performing a jump shot, achieved by players in our study, with those obtained in other studies, results are comparable. Šibila et al. (2003) reported about ball release speed of 24.1 ± 1.3 $m \cdot s^{-1}$ for Slovenian elite team-handball players and Wagner et al., (2010) about 22.3 ± 1.5 $m \cdot s^{-1}$ for Austrian elite handball players. But this is valid only when we compare elite players. In the study performed on students Srhoj et al. (2012) obtained much lower values (19.61 $m \cdot s^{-1}$). It's also interesting that ball velocity is slightly higher in standing shot as it's in jump shoot. In our study ball release speed in jump shoot is 91,35% of those obtained in standing shot. Similar finding is reported by Wagner et al., 2011, where elite team-handball players achieved the greatest ball velocity in the standing throw with run-up (100%), followed by the standing throw without run-up (93%), jump throw (92%) and pivot throw (85%). Authors in this study attribute this phenomenon to the better energy transfer from lower body to the throwing arm in standing throw with run-up compared to the jump and pivot throw (Wagner et al., 2011).

We may conclude from our results that anthropometric parameters and throwing velocity in both shoot techniques are in a significant positive relationship. The effect size is mostely between small and medium. In all anthropometric parameters correlations are higher in a case of jump shoot in comparison with standing shoot. The highest correlation was obtained between body height and jump shoot. In the literature we can find similar findings. Srhoj et al. (2012) claim that high shot velocity is primarily based on emphasized longitudinal dimensionality of dominant arm skeleton which, by using the longer levels, provides larger throw-out movement amplitude and longer influence of muscle force on a ball. Results of study conducted by Wagner et. al (2010) suggest that team-handball players who are taller and of greater body weight have the ability to achieve a higher ball release speed in the jump throw. Apart of body height and body mass also parameters of transversal dimensions and circumferences showed a significant correlations with throwing velocity. High and significant ($r > 0.508$, $p < 0.001$) correlation to the ball velocity achieved in jump shot were found for Bi-acromial diameter.

Among circumferences forearm shoved the greatest correlation with ball velocity in both shots. The importance of forearm muscles strength was pointed out also in a research of Srhoj et al. (2012). All this data showed that body robustness is not important only for the performance of various actions that involve body contact, which is typical of many actions in handball. Trainers have to be familiar with the morphological body characteristics that players should have to perform the tasks required by individual playing positions with the greatest efficiency (Šibila & Pori, 2009). The tallest players should thus be oriented to back player positions – one of the most important reasons is that they have to perform shots from a large distance and with a very high velocity. In this context, trainers should take into account some anthropometric characteristics during handball talent selection because they tend to be a requirement for future high-level performance. In our study we focused only on relationship between some anthropometric parameters and handball shot velocity. To obtain a complete impression about factors which influence a handball shot velocity there are many more factors which should be taken into account. Explosive strength, strength of the forearm muscles and agility are among the most important (Srhoj et al., 2012). Beside this, attention should be focused on training's informational component, i.e. learning and improving the motor knowledge especially the one of the correct technique of the throw-out movement (Srhoj et al., 2012). Thereby, players could better realize their basic potential on anthropometric and motoric level.

References

Bravničar, M. (1987). Antropometrija – priročnik za študente Fakultete za telesno kulturo in trenerje [Anthropometry - a handbook for students of the Faculty of Physical Education and coaches]. Ljubljana: Fakulteta za telesno kulturo.

Rogulj, N., Foretić, N., Srhoj, V., Čavala, M. & Papić, V. (2007). Utjecaj nekih motoričkih sposobnosti na brzinu lopte kod udarca u rukometu. *Acta Kinesiologica, 1*(2), 71-75.

Srhoj, V., Rogulj, N., Papić, V., Foretić., & Čavala, M. (2012). The Influence of Anthropological Features on Ball Flight Speed in Handball. *Collegium Antropologicum 36*(3), 967–972.

Šibila, M., Pori, P., & Bon, M. (2003). Basic kinematic differences between two types of jump shot techniques in handball. *Acta Universitatis Palackianae Olomucensis Gymnica, 33*(1), 19-26.

Šibila, M., & Pori, P. (2009). Position-Related Differences in Selected Morphological Body Characteristics of Top-Level Handball Players. *Coll Antropol*., 33(4), 1079-1086.

Vila, H., Manchado, C., Rodríguez, N., Abraldes, J.A., Alcaraz, P.E., & Ferragut, C. (2012). Anthropometric Profile, Vertical Jump, and Throwing Velocity in Elite Female Handball Players by Playing Positions. *Journal of Strength & Conditioning Research, 26*(8), 2146-56.

Wagner, H., Buchecker, M., von Duvillard, S. and Müller, E. (2010). Kinematic description of elite vs. low level players in team- handball jump throw. *Journal of Sports Science and Medicine 30*, 760-765.

Wagner, H., Pfusterschmied, J., von Duvillard, S.P., & Müller, E. (2011). Performance and kinematics of various throwing techniques in team-handball. *Journal of Sports Science and Medicine 10*, 73-80.

Whiting, W.C., Gregor, R.J. and Halushka, M. (1991) Body segment and release parameter contributions to new-rules javelin throw- ing. *International Journal of Sport Biomechanics 7*, 111-124.

EVOLUTION OF ROLES IN THE HANDBALL TEAM AND THEIR INFLUENCE ON PERFORMANCE: A CASE STUDY

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Abstract: In this study, we started considering the necessity of "mapping" all the roles assumed by each member of the handball team, followed by the application of an intervention program based on action methods. Through the program, these roles can be recognized by each member and then harmonized between them for greatest performance, which is the ultimate goal of a coherent and cohesive running team.

Keywords: handball, team, cohesion, roles, performance.

Introduction

Team spirit, defined from the technical point of view (Bull, S.J., 2011, p. 192), arises in two ways: as a synergy and a confluence. In the first case, it is about the creative energy expressed by a group of individuals whose strength and ability, as a whole, is greater than the sum of those possessed by each one separately. In the second case, it is about the sensation of belonging felt by each member of the team. A group who has team spirit offers the individual two major advantages: an additional source of determination in the moments of stress and a clear reaction regarding one's personal performances.

Since sports performance has physical, technical, emotional and mental components, it is needed an exchange of sincere feedbacks between the members of the same team. As these ones are normally provided by the coach and other team members, the quality of the relationship and communication between athlete and team directly influences the achieved performance. Sincere reactions occur only when the team members trust one another, respect one another and team spirit exists.

Any athlete, regardless of the sports discipline practiced, can improve his/her team spirit and, consequently, personal performances, opening or strengthening the communication channels with those in the team to which he/she belongs. The main idea is that programmed psychological preparation of the team may accelerate this process, with visible results in the achieved performances.

In the psychological preparation of the team, we chose to use the action methods as a type of intervention in the sports group, they including sociodrama and psychodrama:

Sociodrama refers to the exploration of a problem involving a role or a role relationship, a theme that might be relevant to a group of people (Blatner, A., 1996, p. 10). In other words, sociodrama is a social learning activity based in a group setting (Wiener, R., 1997, p. 106). Participants explore an issue that reflects the interest of group members.

Psychodrama, in contrast, addresses the particularities of a single person who is a nexus of many roles (Blatner, A., 1996, p. 11), and more, specific role relationship – not only with a coach and player, for example, but with this specific coach with unique qualities, and a particular player with certain abilities and problems.

An issue of great interest raised by the group task solving is how the roles are assigned in relation with the task. Each role appears as an association of individual and collective elements that confer quality to the role, ensuring the unique adaptation of the individual (Tonita, F., Alexandrescu, N.C., 2014).

There are roles concerning the work itself (task-focused ones), roles related to the group building and continuance (oriented to the group functioning) and individual roles, but their goal is individual and irrelevant to both the group task and functioning (Neculau, 2007). A team is not a bunch of people with job titles, but a congregation of individuals, each of them having a role which is understood by the other members. Members of a team seek out certain roles and they perform most effectively in the ones that are most natural to them (Belbin, http://www.belbin.com/rte.asp?id=8).

Purpose

The purpose of this study is to investigate the potential links between using action methods, like psychodrama and sociodrama in a handball team, and their effects on team performance.

Development of the research

General hypotheses: Each team member is assigned a set (repertoire) of roles to be performed within that team, roles that can be in different stages of development (less developed, moderately developed and well-developed roles). By measuring these roles, a clear direction of intervention can be established, in order to obtain a high degree of cohesion in the team. Psychological preparation of the team, carried out using action methods (psychodrama and sociodrama), can lead to a change of roles in the team, in terms of increasing cohesion and, implicitly, the performances achieved by the team members.

Subjects: The study was conducted over a period of 12 months (April 2014 - April 2015), having as subjects 7 female players in the handball team "CSU Stiinta" of Bucharest, a team participating in the national championship, division A (2^{nd} league). The investigated players are aged between 17 and 38 years. The female athletes taking part in the tests represent the core team and are those who have become members of the team squad at least 6 months before starting the research. The "CSU Stiinta" team ranked 4^{th} in the competitive season 2013-2014 and, in the competitive year 2014-2015, the coach's objective was to build a homogeneous and competitive team, so that its promotion to the National Handball League, in the competitive year 2014-2015, could be approached.

Method: To measure the team roles, we used the Team Role Inventory (Belbin), the initial variant that includes eight roles (Tonita, F., Alexandrescu, N.C., 2014). The Belbin Team Role Inventory, also called the Belbin Self-Perception Inventory, is a tool used to measure preference for different team roles. It was conceived and developed by M. Belbin, following the study of numerous teams at Henley Management College (Belbin, 1984). The Inventory assesses how an individual behaves in a team environment. Belbin specifies that the team roles are not equivalent to personality types and that the Belbin Inventory scores people on how strongly they express behavioral traits from the eight different roles. Thus, a person may often exhibit strong tendencies towards multiple roles. Each of these roles is valuable in the team, and there are not main or secondary roles. However, it is not absolutely necessary for each team to include eight persons, only the roles must be present. In small teams, a person may have more than one role. If too many persons perform the same role, an imbalance will arise, because too few roles are practiced and the tasks are not completed. In small teams, a person must perform many roles. The full set of roles is very important in the situations when rapid role changes occur.

Description of the Nine Team Roles (http://www.belbin.com)

The eight Belbin Team Roles are shown below, along with the strengths and allowable weaknesses for the particular role. According to Belbin Team Role theory, as each Team Role makes an individual contribution to the team, so each Team Role has an allowable weakness, which is the flipside of the strength.

Table 1. Belbin Team Roles (http://www.belbin.com)

Team Role	Contribution	Allowable Weaknesses
Plant	Creative, imaginative, free-thinking. Generates ideas and solves difficult problems.	Ignores incidentals. Too preoccupied to communicate effectively.
Resource Investigator	Outgoing, enthusiastic, communicative. Explores opportunities and develops contacts.	Over-optimistic. Loses interest once initial enthusiasm has passed.
Coordinator	Mature, confident, identifies talent. Clarifies goals. Delegates effectively.	Can be seen as manipulative. Offloads own share of the work.
Shaper	Challenging, dynamic, thrives on pressure. Has the drive and courage to overcome obstacles.	Prone to provocation. Offends people's feelings.
Monitor Evaluator	Sober, strategic and discerning. Sees all options and judges accurately.	Lacks drive and ability to inspire others. Can be overly critical.
Teamworker	Co-operative, perceptive and diplomatic. Listens and averts friction.	Indecisive in crunch situations. Avoids confrontation.
Implementer	Practical, reliable, efficient. Turns ideas into actions and organizes work that needs to be done.	Somewhat inflexible. Slow to respond to new possibilities.
Completer Finisher	Painstaking, conscientious, anxious. Searches out errors. Polishes and perfects.	Inclined to worry unduly. Reluctant to delegate.

The eight Team Roles can also be categorized as Action, Social and Thinking roles:
- **Action** – Completer Finisher (CF); Implementer (IMP); Shaper (SH)
- **Social** – Coordinator (CO); Resource Investigator (RI); Teamworker (TW)
- **Thinking** – Monitor Evaluator (ME); Plant (PL).

Results and discussions

After administering the Team Role Inventory, the results obtained were the following:

Table 2: *Results in the 1st testing (April 2014)*

Name of the athlete	I	C	M	IN	IR	ME	LE	F	Position
G.I.	23	8	0	10	4	8	9	8	CB
S.M.J.	12	4	14	5	2	0	21	12	RB
B.G.	15	0	5	1	13	8	18	10	P
L.L.	10	0	8	0	14	5	12	21	RW
P.A.	9	10	6	9	6	8	16	6	RB
S.D.	8	12	7	4	10	15	6	8	LW
T.A.	10	4	10	2	11	4	16	13	LB
TOTAL	**87**	**38**	**50**	**31**	**60**	**48**	**98**	**78**	
MIN	**8**	**0**	**0**	**0**	**2**	**0**	**6**	**6**	
MAX	**23**	**12**	**14**	**10**	**14**	**15**	**21**	**21**	
MED	**12.43**	**5.43**	**7.14**	**4.43**	**8.57**	**6.86**	**14.00**	**11.14**	

Table 3. *Results in the 2nd testing (April 2015)*

Name of the athlete	I	C	M	IN	IR	ME	LE	F	Position
G.I.	17	10	15	2	5	5	9	7	CB
S.M.J.	14	9	3	2	7	3	19	13	RB
B.G.	5	5	3	4	6	18	14	15	P
L.L.	4	0	2	5	4	8	24	23	RW
P.A.	10	4	8	9	8	3	17	11	RB
S.D.	2	6	12	0	6	17	19	8	LW
T.A.	9	5	11	3	7	7	17	11	LB
TOTAL	**61**	**39**	**54**	**25**	**43**	**61**	**119**	**88**	
MIN	**2**	**0**	**2**	**0**	**4**	**3**	**9**	**7**	
MAX	**17**	**10**	**15**	**9**	**8**	**18**	**24**	**23**	
MED	**8.71**	**5.57**	**7.71**	**3.57**	**6.14**	**8.71**	**17.00**	**12.57**	

CB - center back, LW - left wing, RW - right wing, LB - left back, RB - right back, P – pivot

The athlete **L.L.** was, at the moment of initial testing, the team's top scorer, therefore she also assumed the role of Completer Finisher in all matches, and at the moment of final testing, she was still the team's top scorer, having at the same time the highest percentage of decisive attacking phases and the best percentage in the team's defensive actions.

The athlete **G.I.**, as a center back of the team, assumed the role of Shaper, to the detriment of that of Plant. This led to an increased percentage of successful attacks and less technical-tactical mistakes made by the team. The team was playing with more determination, but without spectacular and improvised actions.

The athlete **S.M.J.** plays within the team as a right wing, but during the championship, she was used as a center back, which was also reflected in the test results, she assuming the role of team Coordinator. At the same time, her individual actions revealed an increased percentage, which was reflected by the lower percentage corresponding to the Teamworker.

The pivot represents the position that must largely help and support the teammates' technical-tactical actions. The athlete **B.G.** – as a pivot of the team, initially assumed the dominant role of Teamworker and the secondary role of Implementer; the change of team's technical-tactical actions made the athlete become the team Monitor and second Completer Finisher.

P.A., a 9m player with a strong shot to goal, was a good Teamworker, but who did not assume actions during the games. After the specific preparation period, she understood that she was one of the team's "gunners" and started getting more involved in the team's play, becoming more active. She had the highest percentage increase in the role of Completer Finisher.

The most experienced athlete was **S.D.** – the left wing of the team. Initially, she assumed the role of team Coordinator and Monitor, the teamwork being inconvenient to her. After the final testing, the main role assumed was that of Teamworker and Monitor.

The team won an athlete who, during the games, not only gave indications on the development of technical-tactical actions, but also participated in the attack actions of the team, even assuming almost all the difficult moments of the game as a Completer Finisher.

T.A. was the athlete who kept the initially assumed roles, that of Teamworker and that of Completer Finisher.

The athletes **B.G**. and **S.D.** assumed the role of Monitor, which led to contradictory discussions and conflicts within the team. The coach changed the orientation of technical-tactical actions, so that there were never two monitors on the field in the same time.

Conclusions

After one year of experiment, the team showed the highest percentage for the Teamworker. This was also highlighted by the fact that the "CSU Stiinta" team had the best defense in the competitive year 2014-2015, at the second league level. The team's objective was fulfilled, as it was ranked 2nd in the group, which led to its presence in the play-off tournament to qualify for the National Handball League. The coach's knowledge about the roles assumed by the female athletes led to refocusing the training process and changing the team's tactics. The coach could identify the vulnerable parts of the team and, together with the psychologist, improved or even changed the athletes' orientation towards the roles appropriate to each of them.

References

Belbin, M. (1984), *Management Teams: Why they succeed or fail,* London: Heinemann

Blatner, A. (1996), *Acting-In. Practical Applications of Psychodramatic Methods*, New York, Springer Publishing Company, pp. 10-11

Bull, S.J. (2011), *Psihologia Sportului. Ghid pentru optimizarea performanțelor*, București, Ed. TREI, pp. 192-193

Neculau, A. (2007), *Dinamica grupurilor și a echipei*, Iași, Editura Polirom, pp. 301

Tonita, F., Alexandrescu, N. C. (2014), The Technical-tactical training optimization through the role assumption in the handball team, Bucharest, 4th International Congress of Physical Education, Sports and Kinetotherapy

Wiener, R. ((1997), *Creative Training. Sociodrama and Team-Building*, London, Jessica Kingsley Publishers, pp. 106

http://www.belbin.com/rte.asp?id=8

http://www.belbin.com/content/page/5596/BELBIN(uk)-2013-A%20Comprehensive%20Review.pdf

CONTROL PSYCHOMOTOR FUNCTION BY QUALIFIED HANDBALLERS

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SUMMARY

There are a lot of and a number of studies have been performed as to the importance of facilities use in sportsmen training. Nowadays, when the amount of training load comes to quite high values, further improvement of sportsmanship in many aspects depends on intensification of the workout process. Skilled application of exercise machines and training devices plays an important role in intensification and improvement of performance during the workout process. The aim of the research is justification the control of training by qualified handballers with special technical devices. The necessity to use facilities during workout sessions in handball has been ascertained. Novel informative testing techniques using flashlight tests have been discussed. Application of test exercises, aimed at evaluation of psychomotor system by qualified handball players of the Ukrainian Super League, has been analyzed.

Keywords: handball, test, workout psychomotor system

INTRODUCTION

Some, training devices hold a prominent place in teaching sportsmen the handball playing technique (Leykin, 1999). The others unite separate elements of the technique into a whole movement. When specific capacity is developed properly and training devices are used skillfully, sportsmen acquire reasonable technique. In case there are mistakes during technique attainment, then the training devices are used for their elimination (with the selective influence on separate elements or the whole technique) (Popov, 1999).

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Generalized present-day knowledge of fundamentals of facilities allows us to choose the most advanced applications of exercise machines or new generation devices for workout process (Vodlozerov, 2011; Mokina, 2008). The issue is that correct goal-oriented use of exercise machines brings positive results and great achievements in sports (Alabin, Skripko, 1979). We can assume that the correct choice of exercise machines for workout sessions or testing is an important stage in the use of facilities. They are indispensable for the management and efficient workout process, which gives opportunity to promptly and objectively collect information about readiness of a sportsman's body (Yushkevich, Vasyuk, Bulanov, 1989).

Our own experience of scientific-practical work with combine teams and teams of Super league of Ukrainian championship, analysis of modern literature, devoted to this problem, give understanding that today one of problems is discordance of theoretical works about sport games and their insufficient implementation in practice. It permits for us to think this problem to be really urgent.

METHODS

This study included 65 male highly qualified handballers (age=23.48±3.68 years) from candidate master of sports (CMS) to international master of sports (IMS) of Ukraine by three teams competing in the Super League Ukraine "Motor", "ZTR", "ZNTU-ZAB" Zaporizhzhya. Teacher supervision took one microcycle (3 days). The objectivity of the information has been provided by adherence to the standard conditions:

- teacher supervision was performed in the morning from 9.00 AM till 12.00 AM;
- exercises for evaluation have been performed after a basic lead-in and warming up of qualified handball players;
- the results of psychomotor function have been determined at a separate training session;
- repetition of exercise (tries) has been performed after a rest and after the sportsmen reached the heart rate below 110 bpm.

RESULTS

In order to evaluate special condition (psychomotor function) of handball players, analysis of standard practices and specific character of competition-based activity in handball allowed us to propose and implement the following test exercises into the workout process of qualified teams of the Ukrainian Super League: the Flashlight Test (FlT), the Flashlight Handball Throw Test (FHTT) and the Complex Flashlight Handball Test (CFlHT). They are of crucial importance in most game situations and to the full extent reflect the following technical and tactical actions of players and a team during competitions:

- active counteract to the attack of the opponents,
- correction of technical and tactical actions in response to the change of the system of offense,
- switch of defensive players while marking offense,
- performance of backup and parallel movement in defense,
- performance of attacks and defensive technical and tactical actions in the setting of numerical disadvantage, majority in number etc.

The Flashlight Test (Tyshchenko, 2014) allowed us to determine the attention switch rate and special capacity of handball players under conditions of active choice of useful information (Fig.1). The structure of exercise performance was the following: 5 stands with LED lamps were located in the center of the 9-meter line (line of active defense).

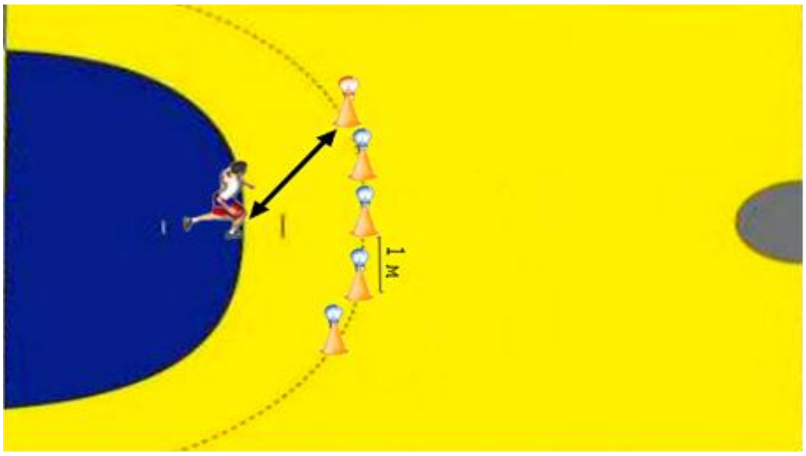

Fig. 1: *Flashlight Handball Test (FlHT) performance scheme*

It should be noted that LED lamps have been used as a signal stimulus during performance of an exercise. The flash of one or another lamp was controlled by computer application of basic random numbers. The distance between the stands was 1 m. A handball player started doing the exercise from the middle of the 6-meter line (the goal line). On a coach signal, the sportsman dashed from the standing start to the stand, where the light flashed. When he touched the stand, he ran back to the starting place. During the exercise performance the number of touches of the stand during 30 second has been counted. To get the better result qualified handball players had two tries for the performance of this exercise.

The sportsmen have performed the Complex Flashlight Handball Test (CFlHT) from the standing start on the signal of a coach (Fig.2).

It involved performance of the basic technical and tactical actions in handball: movement with change of direction, ways of movement (forward and backward, sidesteps and cross steps), ball pickup and dribbling throw of the ball on the goal square, above which the light flashed. To provide performance of the exercise in the middle of the 6-meter line (goal line) and 9-meter line (active defense line) the stands (4 in all) have been located on the both sides of the playground. The performance of this exercise started from the 6-meter line and involved three runs around the first couple of stands on the first half of the playground acceleration to the second half of the playground (B) and tree runs around the second couple of stands. After this, the ball, located near the stand at the 6-meter line of the second half of the playground, was picked up, then - dribbling from the 9-meter line of the first half of the playground, and the jump shot was performed on the same half of the playground. It should be noted that the stands have been run around (on the A and B halves of the playground) forward to the central line. In this wise the sportsman ran forward from the 6-meter line to the 9-meter line, and backward from the 9-meter line to the 6-meter line. Running in this section from the one half of the playground to the second one and dribbling were forward. The time for performance of the test exercise has been registered from the moment the sportsman started the movement on the 6-meter line until the ball crossed the goal line.

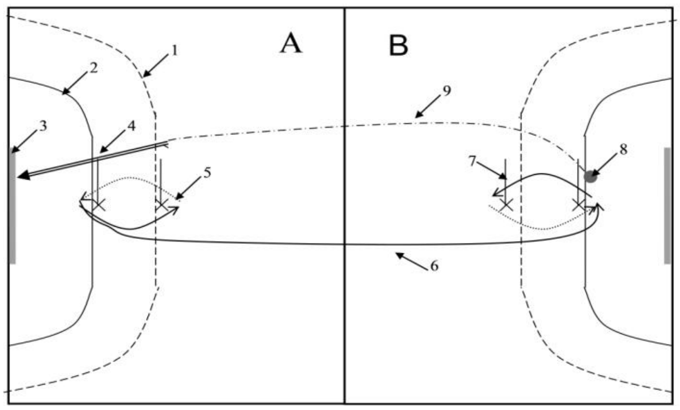

Fig. 2: *Complex Flashlight Handball Test (CFlHT) performance scheme: A, B – halves of the playground, 1 – 9-meter line (line of active defense), 2 – 6-meter line (goal zone), 3 – goal, 4 – throw, 5 - backward run, 6 – forward run, 7 – stands, 8 – ball, 9 – dribbling*

With the help of the Flashlight Handball Throw Test (FlHTT) the rate of technical competence has been monitored in game situations, related to active attacks, in situations of set offense, as in counter-attacks and in drawing of standards. The performance of this test exercise involved the use of basic effectively significant technical and tactical actions during attack by qualified handball players: movement with change of direction, way of movement (forward and backward, sidestep and cross-step), handling, throwing the ball on the goal.

The content of the routine involved alternate regulated performance of throws on the goal by qualified handball players after handoff from co-instructors. Starting location for the exercise -

12m from the face line (3 meters from the 9-meter line of active defense). The sportsmen had two acceptance trials, the best of which was scored (Fig. 3).

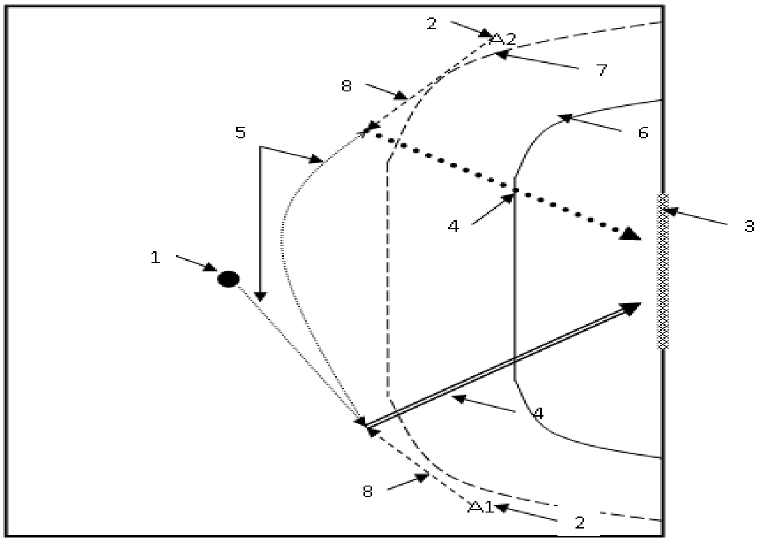

Fig. 3: *Flashlight Handball Throw Test (FlHTT) performance scheme: 1 – sportsman, 2 – co-instructors, 3 – goal, 4 – throw, 5 – sportsman's movement, 6 – 6-meter line of the goal zone, 7 – 9-meter line (line of active defense),8 – handling of the ball from the co-instructor to the sportsman*

The sportsman must alternately perform throws from the 9-meter line after movement along it to one or another side. It should be noted that that the throws have been performed into the goal square, above which the light flashed. The total time for performance of the exercise was 30 sec and it has been recorded from the moment the first throw had been made. Within this time the number of balls, thrown exactly into the relevant areas, has been calculated.

DISCUSSION

The study of various types of psychomotor response of sportsmen has not only theoretical, but, in the first place, practical importance in the selection of space-time regimens for movements management when teaching techniques of new exercises and performing set of exercises. The two components can be distinguished in the motor response: sensor, which is characterizing information perception, and motor, which is directly responsible for the movement. However, in the setting of competition-based activity, handball players must display the complex of these components in a good manner.

In this wise, we can state that training facilities for improvement of significant number of specific physical properties (coordination, speed endurance, technical endurance etc) can be used to enhance overall performance of special condition of qualified handball players. In addition, efficient training facilities, aimed at improvement of coordination skills of sportsmen, should be used.

CONCLUSIONS

During CFlHT, orientation in mid-air, balance in combination with speed performance (agility) are dominating and for performance of FlHT latent time of complex reaction and the time of single movement have the same significance. Coordination skills and the extent to which they are developed are closely connected with formation of technique for sport exercises (Portnov, YU.M. 1996; Bulkin, V.A. 1983). Taking this into consideration, it can be assumed, that the use of facilities, aimed at development of special coordination skills, shall have positive effect on the level of technical competence of sportsmen and, particularly, the realizable component of technical and tactical actions of qualified handball players.

PROSPECTIVE OF THE FURTHER RESEARCHES

Performed research does not cover all the sides of the analyzed problem. It confirms the necessity of precise attention to the further deep theoretical-methodological work and improvement of realization practice for the innovative control system into the preparation system of the higher qualification handball teams. The main goal for the further usage of this information – definition of the potential possibilities, their correspondence to the demands and correction of the preparation process.

References

1. Alabin V.G., Skripko A.D. (1979). Trenazhery i trenirovochnyye ustroystva v fizicheskoy kul'ture i sporte (Simulators and training devices in physical culture and sports), Minsk: Higher School, 170-176.
2. Bulkin, V.A. (1983). Kompleksnyy pedagogicheskiy kontrol' v sisteme podgotovki kvalifitsirovannykh sportsmenov, LNIIFK, 3-14.
3. Leykin M.G. (1999). Nauchnoye obosnovaniye i sozdaniye sportivno-ozdorovitel'nykh trenazherov (Scientific justification and creation of sports and fitness trainers), dis. dr. ped. of sciences, Moscow, 88-94.
4. Mokina Ye. (2008). Psikhologicheskiye pokazateli kvalifitsirovannykh gandbolistok kak kriteriy ikh podgotovlennosti k sorevnovatel'noy deyatel'nosti, Nauchnyye issledovaniya i razrabotki v sporte (Scientific researches and development in sports): messenger of postgraduate study and doctoral studies. T. 17, The national state. un-t physical. cultures, sports and health of P.F. Lesgafta, SPb., 108-116.
5. Popov G.I. (1999). Biomekhanicheskiye osnovy sozdaniya predmetnoy sredy dlya formirovaniya i sovershenstvovaniya sportivnykh dvizheniy (Biomechanical bases of creation of the subject environment for formation and improvement of sports movements), dis. dr. ped. of sciences, Moscow, 78-82.
6. Portnov, YU.M. (1996). Osnovy upravleniya trenirovochno-sorevnovatel'nym protsessom v sportivnykh igrah, M., RGAFK, 200.
7. Tyshchenko V. Method for tests assessment of psycho-physical by qualified handballers**:** patent 86795 Ukraine, МПК А63В 69/00 (2013.01). − № u201308846; claimed 10.01.2014; published 10.01.2014; bull. №1.
8. Vodlozerov V.Ye. (2003). Trenazhery lokal'no napravlennogo deystviya (Trainers locally directional), Kiev: Publishing Center KSMU, 96-102.
9. Yushkevich T.P., Vasyuk V.Ye., Bulanov V.A. (1989). Trenazhery v sporte (Exercise machines in sports), Moscow, Physical Education and Sport, 182-186.

SELF-CONSCIOUSNESS ON THE EFFICIENCY OF QUALIFIED HANDBALLERS REHABILITATION

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ABSTRACT
Empirically explain the role of the individual identity of the qualified handballers on the effectiveness of rehabilitation after injury. The experiment involved 22 athletes, representatives of handball. All athletes had injuries of the musculoskeletal system and began moderate rehabilitation period. The study used specially adapted test evaluation grids to determine the level of anxiety. It was determined that personified psychological work should be aimed at optimizing the internal installations of athletes. It affects the speed and quality of the rehabilitation process, improves the selective ability of the individual, positive impact on their career. Found that increasing the amount of information in the personal construct increases the level of personal development. It is advisable to include the theory of personal constructs in a program of psychological rehabilitation of athletes.

Keywords: qualified handballers, constructs, consciousness, psychology, rehabilitation.

INTRODUCTION
Nowadays one of global problems of sports branch is the problem of traumatism. High intensity of sports, with unfavorable and stressful for health situations, is connected with the whole complex of risks, consequences and results that leads to traumas [1]. Statistical data, received in different kinds of sports, show that traumatism level is still steadily high and have a trend to grow. As far back as 40 years ago the quantity of sports traumas in the world was a little more than 1% of total traumatism. At present, in different countries of the world the quantity of traumas in professional sports varies within 10-17% of total traumatic cases [2]. Trauma is a serious test of sportsman's will power of his inner settings. The way, how a sportsman response to trauma depends, first of all, on his individual features. Trauma results in compelled pause, the importance of which is not always understood by sportsmen. By its nature, such pause cannot be definitely related to destructive phenomenon, because it is ambivalent. It bears both: latent potential for self-cognition and rising of sportsmanship and it can undermine sportsman's faith in his self, bring to zero all previous achievements [3]. Malinauskas, R. studied correlations between the heaviness of trauma and its sensing and satisfaction with life [4]. Sportsman understands his inner world with the help of conceptual systems or models, which he creates and then tries to adapt to objective reality. It is not always successful. But still, without such systems the world would be seen as something so undifferentiated and homogeneous, that a person could not be able to comprehend it. Exactly these conceptual systems or models were determined by American psychologist Jh. Kelly in 1955, as personal constructs [5]. Personal construct is a special subjective evaluating standard, created by a person, valid in practice and helps to comprehend and understand surrounding reality, prognosticate and evaluate events. The more complex human personal system of constructs is the more suitable it is for description, analysis and estimation of objects in their contradictory unity [6]. Personal constructs determine human self consciousness, thus, causing first priority interest for research [7].

PURPOSE AND TASKS OF RESEARCH
The present research is aimed to empirically clear up the role of sportsman's individual self-consciousness (by means of analysis and correction of his system of personal constructs) on efficiency of rehabilitation after receiving trauma. For this purpose it is necessary to previously

solve a number of tasks, videlicet: to analyze theoretical approaches to the methods of sportsmen's psychological rehabilitation, role of personal constructs in human life activity; to chose valid diagnostic base and specialized techniques of psychological influence; to evaluate the obtained results with the help of statistic analysis. For our researches we selected 22 qualified handballers, which started rehabilitation period after traumas of supporting motor system of middle heaviness. In the course of the research we used specially adapted test of "evaluation lattice", which is oriented on determination of anxiety level.

RESULTS OF THE RESEARCHES

On the 1st stage of the present research, which was of constructive character, we evaluated the level of anxiety, because the first period after receiving of trauma is characterized by clear neurotic manifestations. For maximal personification of psychological rehabilitation influence we applied specially adapted test of "evaluation lattices", oriented on studying of personal constructs. The difference of repertoire lattices from many other scaling procedures lies in the fact that repertoire lattices are directed not to obtaining information about objects of scaling but to obtaining information about person himself, who fills in this lattice.

In the process of experiment, every respondent received cards, which were arranged in individual order and contained elements (in our case they were eight), which represented the type of role responding to emotionally significant situation. Besides, we gave respondent a card with one construct (in our case such cards were eight and they represented different stressful situations). Number of card with construct was on face side, number of card with elements – on back side. Respondent was asked, which of elements describes his response to situation in the best way. The chosen card with elements was taken away, and, further, the respondent was proposed to select the most suitable element from the remaining. The ranging continued up to the moment, when only one card was on the table. The ranging results were entered in special table, in which constructs were arranged in horizontal order and elements – in vertical.

After ranging of all cards by the first construct, the cards with elements were shuffled and again spread on the table. It was made in order to exclude the possibility of occasional correlations. Further, respondent ranged elements in respect to the second construct. This procedure repeated until elements were ranged in relation to all constructs. After this procedure we obtained matrix of elements' ranging. These elements we turned into range number of every element by each construct and it permitted to carry out statistical analysis of ranging. The list of constructs (see fig.1) and elements, which were selected for our research, is given below:

- E1 (Element 1) – I prefer to evaluate soberly, basing on realistic ideas.
- E2 (Element 2) – I understand that not always depend on myself but many things depend on external circumstances.
- E3 (Element 3) – in any situation I trust myself and rely, first of all, on myself.
- E4 (Element 4) – in such situation I, most often, become nervous.
- E5 (Element 5) – such situation can get me in state of stupor.
- E6 (Element 6) – such situation makes me panic-stricken.
- E7 (Element 7) – I relay on my luck.
- E8 (Element 8) – in any situation I consider team interests as well as mine.

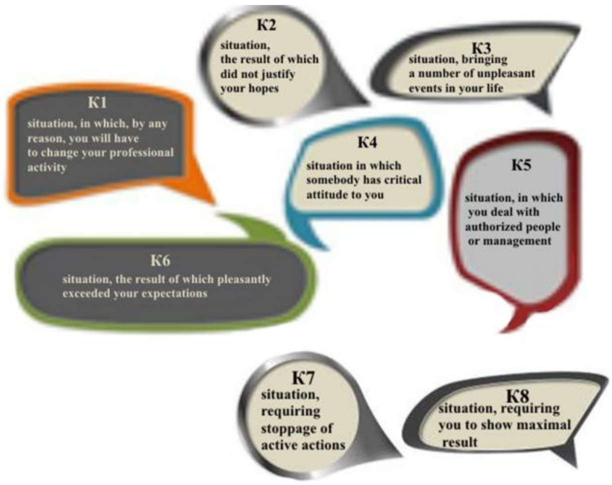

Fig. 1. *Constructs, which were selected for our research performance scheme*

In connection with homogeneity, with analyzing, we took middle ranges of constructs by every of marked out elements. For every pair of constructs the range correlation coefficients of Spirman were calculated. Further, their squares were summed for obtaining two constructs with the largest sum of points of interconnections. After it, all other constructs were located in the space of 2 axes (see fig.2).

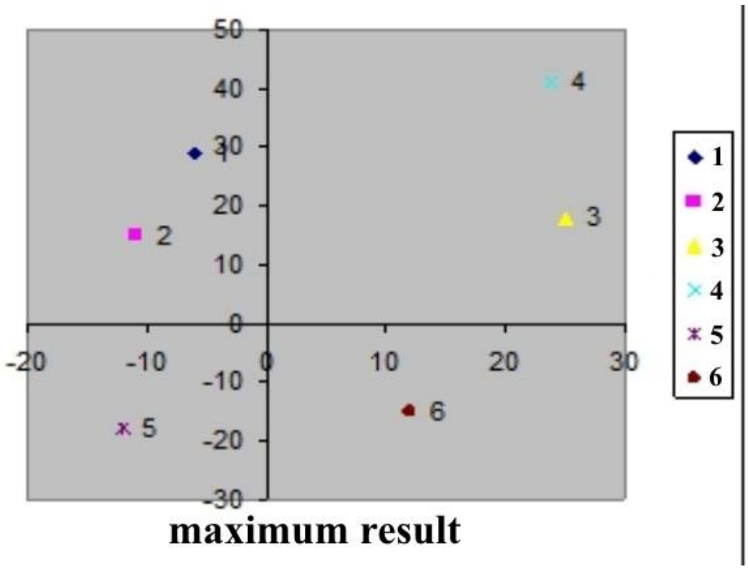

Fig.2. *Location of constructs 1-b in the space of two main axes in compliance with the points of interconnections*

On axis X we put points of constructs' interconnections with main construct 8 (situation, requiring you to show maximal result) and on axis Y – the same with construct 7 (situation, requiring stoppage of active actions). Construct numbers on diagram coincide with their numbers in the list. These data reflect the most dominating general trends.

On the II stage of the research, after analysis of the data, which were obtained on the first stage, psychologists carried out individual psycho-therapeutic work, which was based on constructive alternative approach, with respondents. The results, obtained in processing of data of sportsmen before trauma and receiving it, are presented in fig.3.

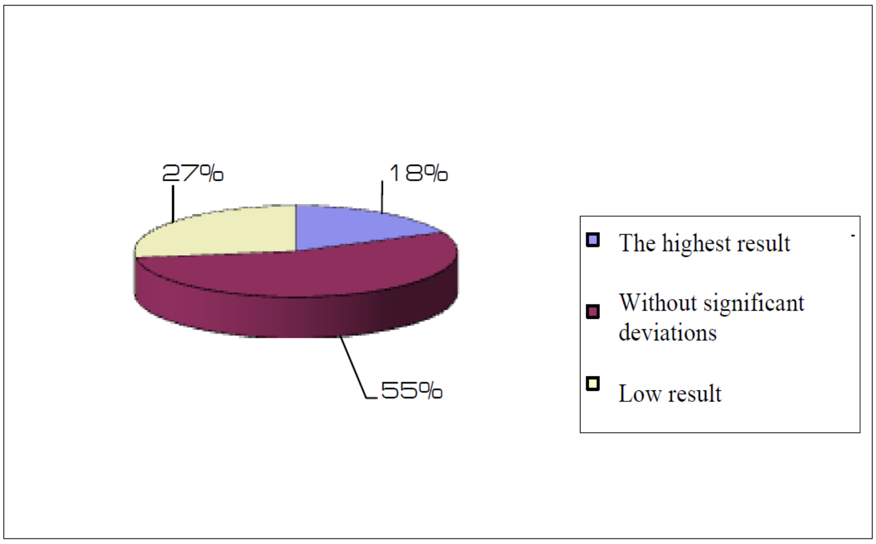

Fig.3. *Results of comparative analysis of the tested before and after receiving traumas*

The characteristic feature of such approach is that the representatives of it avoid imperative moments, have respectful attitude to the wholeness of constructs system, which is intrinsic to sportsman at current moment, and collaborate with sportsman in searching new types of behavior; they are not in opposition to nuclear constructs of identity in existing systems. Psycho-therapist does not prejudice directly the value of sportsman's views, but the helps him to find new, may be more difficult and viable alternatives. Besides, for every sportsman we selected simple auto-suggestive formula, which could help him to overcome certain limiting moments. Comparative analysis of results, obtained on different stages of experiment, is presented in fig. 4. We may state that for many sportsmen traumas result in rapid growth of anxiety, in misunderstanding of prospects, in instability of moral and world-outlook views. The programs of psychological rehabilitation, which are widely spread to-day, are directed to individual features of inner constitution of traumatized person.

We may state that for many sportsmen traumas result in rapid growth of anxiety, in misunderstanding of prospects, in instability of moral and world-outlook views. The programs of psychological rehabilitation, which are widely spread to-day, are directed to individual features of inner constitution of traumatized person.

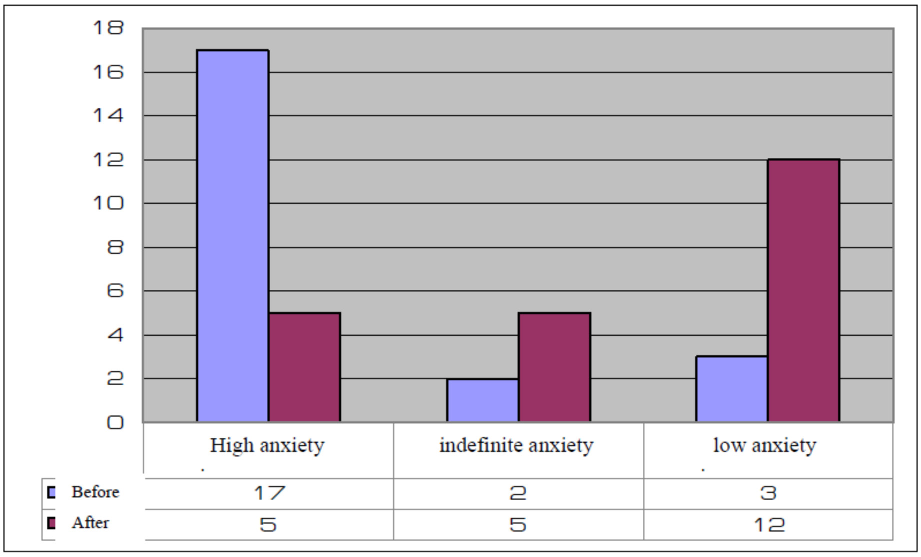

Fig.4. *Results of comparative analysis of respondents anxiety levels before and after rehabilitation*

That is why sportsman cannot always fully emotionally and mentally reconsider and "re-experience" trauma. This results in the fact that very often, after rehabilitation, sportsman spends much time for restoration of previously demonstrated results or receives new trauma.

It can be stated that the more information is integrated in personal construct (providing the wholeness and sense structuring are available) the higher is the level of personal development. The research showed dependence between cognitive complexity of personal construct system and sportsmen's ability for analysis and evaluation, for sensing of objects and events in all variety of their unity. Basing on the above said, it would be purposeful to introduce the theory of personal constructs in the program of sportsmen's psychological rehabilitation. In the whole, this is an up to date branch of cognitive approach to a personality and to mechanisms of personality's study and development, because its influence on efficiency of rehabilitation is rather significant.

The prospects of further researches shall be oriented on psycho-prophylaxis of traumas by working with inner world of a sportsman. Besides, it is possible to study specific gender peculiarities of sportsmen's personal constructs, methods of studying of a person and stimulating personal development.

References

1. Wiese-Bjornstal D. M. Psychology and socioculture affect injury risk, response, and recovery in high-intensity athletes: a consensus statement. *Scandinavian Journal of Medicine & Science in Sports,* 2010, vol.20(2), pp. 103–111.
2. Hootman J.M., Dick R., Agel J. Epidemiology of Collegiate Injuries. Sports: Summary and Recommendations for Injury Prevention Initiatives. *Journal of Athletic Training*, 2007, vol.42(2), pp. 311–319.
3. Walker N. Psychological responses to injury in competitive sport: a critical review. *Journal of the Royal Society for the Promotion of Health.* 2007, vol.127(4), pp. 174–80.
4. Malinauskas R. The Associations Among Social Support, Stress, and Life Satisfaction as Perceived by Injured College Athletes. *Social Behavior and Personality An International Journal*. 2010, vol.38(6), pp. 741-752. doi:10.2224/sbp.2010.38.6.741
5. Kelli Dzh. *Teoriia lichnosti* [The theory of personality], St. Petersburg, 2000, 77 p.
6. Cochran L. R. Construing and acting toward others. *Journal of Health* & *Social Behavior*, 1981, vol.9(1), pp. 37- 40.
7. Adams-Webber J. R. Differences between physical and psychological constructs in repertory grids. *British Journal* of *Medical Psychology*, 1980, vol. 53, p. 319-322.

ANTERIOR CRUCIATE LIGAMENT CLINICAL PATHWAY

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SUMMARY
Two hundred eighty-five ACL reconstructed patients were analyzed before and 3, 6, 12 months after surgery. Isokinetic thigh muscle force, single-leg hop tests, anterior and rotational knee laxity and subjective knee function showed a positive evolution during the rehabilitation period. Six months after the ACL reconstruction, patients however still presented deficits in the operated leg, which should be considered in the decision of return to sport.

KEYWORDS: Anterior cruciate ligament, surgery, epidemiology

INTRODUCTION
Over two millions anterior cruciate ligament (ACL) injuries occur worldwide each year [1]. Scandinavian registers reported that the annual incidence of primary ACL reconstructions is around 85 per 100 000 citizens in patients aged from 16 to 39 years [2]. The majority of these injuries (74%) are non-contact injuries and occur during landing and cutting movements [3, 4]. Two third of ACL injuries occur during sporting activities [5]. In Scandinavia, 20% of all ACL injuries occur in handball [2]. In Luxembourg, these injuries represent 8% of all ACL injuries, and especially concern females (14% of ACL injuries in females) [6]. While ACL reconstruction remains the standard of care, an insufficient proportion of athletes return to sport and a large amount of ACL graft ruptures are observed [7]. A meta-analysis of 5770 patients showed that only 63% of the patients returned to their preinjury level of activity [8]. Furthermore, the risk of sustaining a re-rupture is the highest within the first 12 months after an ACL reconstruction (6%) [9]. The re-injury risk however depends on the population studied and reaches up to 30% in high risk athletes such as elite alpine skiers [10].

The establishment of a standardized clinical pathway may be a strategy to provide an overview of the spectrum of ACL-injured patients [11], the medical and physiotherapeutic care as well as the compliance with recommendation guidelines. In addition, such registries also provide information on procedures and devices resulting in premature failure and on outcome-associated prognostic factors [12]. In Luxembourg, a clinical pathway for ACL tears was developed to monitor patients, adapt their care and enhance successful return to sports. The purpose of the present study was to obtain a picture of muscles force, hop performance, anterior and rotational knee laxity and subjective knee function in a prospective cohort of ACL-reconstructed patients over their pre- and postoperative follow-up.

MATERIAL AND METHODS
Patients
All patients seen in our clinic with an ACL injury were proposed to enter a systematic and standardized follow-up regardless of the treatment decision (operative or nonoperative). Patients were included in the clinical pathway if they had an ACL tear, which was diagnosed clinically and documented on magnetic resonance imaging. All were recruited from March 2011 to September 2014 and signed a consent agreement according to the National Ethics Committee for Research which approved the study protocol (N°201101/05 version 1.0). Data acquisition was notified to the National Data Protection Committee. Only patients presenting an ACL reconstruction were included in this study. Surgically treated patients were operated either with a bone-patellar tendon-bone (BPTB) or hamstring (HS) graft. The latter were evaluated before surgery (preop.) and at 6 weeks, 3 months (3m), 6 and 12 months after the ACL reconstruction.

Description of the ACL clinical pathway

Data were collected prospectively by surgeons, physiotherapists, study nurses and researchers and were saved in a secure database (Fig. 1). The clinical pathway consists of filling in a standardized questionnaire, indicating personal data, sports participation before the injury, previous lower leg injuries and the circumstances of the ACL injury [6]. The Visual Analogue Scale of Pain (VAS), the Knee Injury and Osteoarthritis Outcome Score (KOOS) [13] and the International Knee Documentation Committee (IKDC) subjective forms [14] is completed by the patient before, 6 weeks, 3, 6 and 12 months after the surgery.

Several objective measurements were also included in the pathway. Because early knee motion is favourable for the healing of the graft, the range of motion (ROM) of the knee is measured with a goniometer before ACL reconstruction and 6 weeks after [15, 16]. To measure the patient's balance, the Y-test is performed up to 3 months after the reconstruction of the ACL [17]. This test consists of holding balance on one leg while pushing with the opposite foot an item as far as possible in the anterior, lateral and cross-lateral direction. In order to evaluate the force of the knee extensors and flexors, the peak torque average of 4 repetitions of isokinetic thigh muscle force including concentric hamstring (HSc) and quadriceps force as well as eccentric hamstring (HSe) force were recorded before and 3, 6 and 12 months after the operation on the dynamometer Con-Trex®. To test the knee laxity, anterior and rotational laxity measurements were performed with the GeNouRoB (GNRB) and the Rotameter respectively before surgery and at 3, 6 and 12 months afterwards [18]. Regarding the hop performance, three single-leg hop tests (hop for distance, vertical jump and side hop [19]) were realised at 6 and 12 months of follow-up. Admission criteria for the hop tests were a time span of 6 months after surgery, an isokinetic force deficit under 40%, an IKDC score under 70, no swelling and no knee pain, free ROM, a negative pivot shift as well as subjective knee stability.

Analysis

The present study aimed to report the average and median results obtained by ACL-reconstructed patients at different moments of their follow-up for isokinetic force, single-leg hop tests, anterior and rotational laxity and subjective knee function (KOOS, IKDC). Muscle force and hop performance were computed as the difference in percent of the operated leg compared with the contralateral healthy leg. The side-to-side differences in anterior displacement and knee rotation were expressed in centimeters and degrees respectively. Subjective knee function in sport and quality of life were calculated on a score of 100. All results were presented as a function of time and graft.

Fig. 1: *Data collection of the clinical pathway*

	Operated patients				
	Pre-op	6 w	3 m	6 m	12 m
Questionnaire + IKDC + KOOS + VAS	X	X	X	X	X
ROM	X	X			
Y-test	X	X	X		
Anterior laxity + Rotational laxity	X		X	X	X
Isokinetics	X		X	X	X
Hop test				X	X

Non operated patients

RESULTS

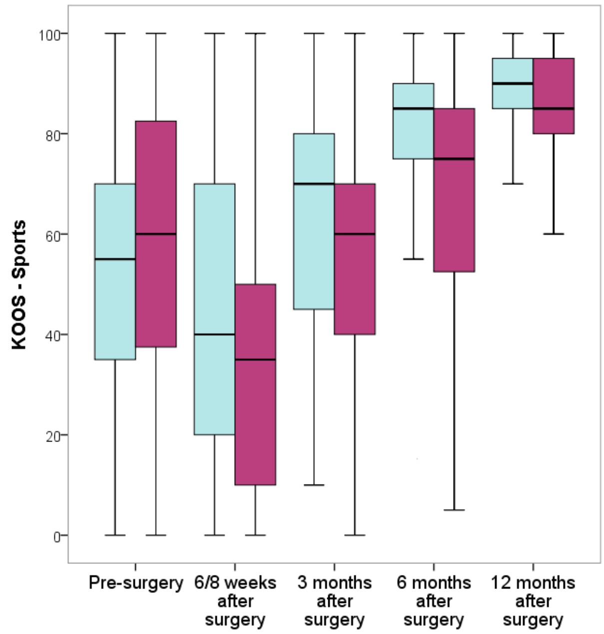
A total of 322 patients were operated between March 2011 and September 2014, of which 285 (88%) patients signed the consent. Thereunder 123 (43%) had a BPTB autograft and 162 (57%) a HS graft reconstruction. Eighty-seven (30%) participants were females.Both patients with a BPTB and HS graft displayed, in average, a deficit in concentric quadriceps force between legs before surgery and at 3, 6, 12 months (BPTB: preop - 21±18% ; 3m - 45±14% , 6m - 28±14%, 12m - 14±14%; HS: 19±15%, 26±36%, 14±15%, 2±18%). The concentric and eccentric hamstring forces were also in deficit in the BPTB group (HSc: 15±17%, 12±15%, 3±17%, -2±15%; HSe: 17±17%, 18±17%, 8±16%, 5±14%) and in the HS group (HSc: 16±19%, 19±20%, 11±20%, 8±12%; HSe: 19±17%, 26±17%, 13±19%, 9±10%) pre- and postoperatively.

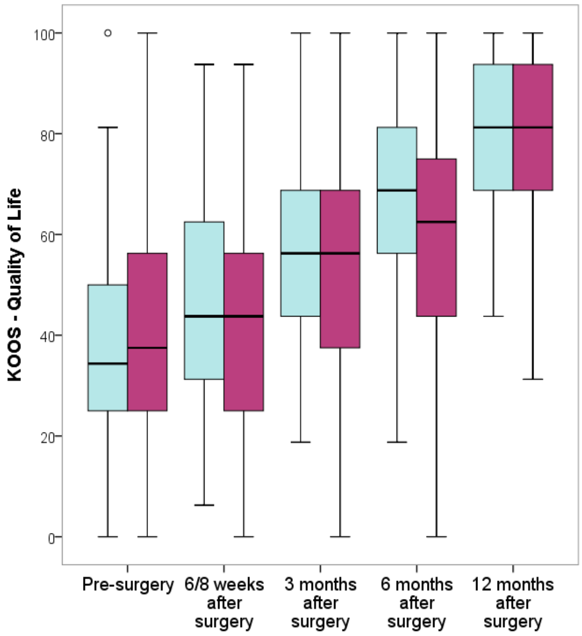
At 6 and 12 months, the operated leg displayed a deficit both in BPTB and HS reconstructed patients in the vertical jump (BPTB: 20±16 and 13±10%; HS: 11±13 and 5±10%;), the hop for distance (BPTB: 12±12 and 7±10%; HS: 7±12 and 2±7%) and the side hop (BPTB: 18±22 and 9±14%; HS: 12±17 and 3±12%). Anterior knee laxity measurements showed an increased side-to-side difference in the ACL-injured leg pre-operatively (BPTB: 2.4±1.7mm; HS: 2.1±1.7mm). This difference was diminished after surgery (BPTB: 1.0±1.3, 1.4±1.3, 1.1±1.4mm; HS: 1.0±1.6, 1.1±1.7, 0.6±1.mm). A side-to-side difference was also measured on the Rotameter before and after surgery (BPTB: 1.8±2.9, 2.1±2.9, 2.3±2.8, 1.0±2.8°; HS: 2.1±2.9, 1.8±3.5, 2.3±2.5, 1.7±2.8°).

The average scores of the different KOOS subscales (pain (P), symptoms (S), activity in daily living (ADL), sports (SP) and quality of life (QoL)) increased from the preoperatively period (BPTB: P - 80±16, S - 74±17, ADL - 87±14, SP - 59±26 , QoL - 40±23; HS: 73±18, 70±18, 82±17, 50±26 and 36±21) up to 12 months after surgery (BPTB: 90±9, 88±10, 97±6, 84±14 and 74±23; HS: 95±6, 90±9, 99±2, 90±10 and 78±19) for both graft groups. Score distribution was less expanded throughout the follow-up. While in the preoperative period the range reached a score between 0 and 100, 12 months after the ACL reconstruction, scores only varied between 80 and 100 (Fig. 2). Compared to the preoperative evaluation, the IKDC scores showed also a good progression one year after rehabilitation (BPTB: preop - 66±16, 12m - 87±14; HS: 61±16, 91±8).

Fig. 2: KOOS Sports and Quality of Life scores

The BPTB graft group is represented in purple, the HS group in blue. The black line in the box-plot represents the median, 50% of the data is greater than the middle of dataset. Each of both vertical lines extending from the box represents a quartile, including 25% of the participants.





DISCUSSION

The presented clinical pathway allowed to describe the average progression of ACL-reconstructed patients through their rehabilitation period. The decreasing side-to-side differences in knee laxity measurements after surgery indicated a good stabilisation of the knee after surgery. The initial deficit of the isokinetic thigh muscle force and hop performance tended to decrease and subjective knee evaluation scores to increase. It should however be highlighted that even after 6 months of rehabilitation, patients still had deficits compared to the healthy contralateral leg.

The objective of the present study was to quantify the evolution of ACL-reconstructed patients during their rehabilitation phase and to set normative references of their functional knee capacity at one year of follow-up. The different aspects of injuries are presented as defined by the International Classification of Functioning, Disability and Health were integrated into the present follow-up: impairment of the body functions and structure, limitation in activities and restriction in participation [20, 21].

The deficiency of the operated leg at 6 months after surgery should be considered in the decision of the appropriate moment of return to sport [22]. Whether one or several evaluated aspects of knee function is in relation with ACL injury risk is nowadays still unknown. An answer to this question would be helpful in order to improve injury prevention and provide a safe return to sport.

The present study is not without limitation. First the heterogeneity of our population according to gender, age, sport level and previous and associated knee injuries may influence our results. In the future, this systematic follow-up may permit an early identification of high risk patients for return to sport. Further studies establishing specific references dedifferentiating patient's profiles according to age, gender, sport level, associated knee injuries and graft type are required in order to individualize care [20, 21]. All patients were recruited from the same hospital so that our references may be specific of our patient population. As such, they may be used with caution in other populations. Besides the patients which did not meet the hop test inclusion criteria were not taken into consideration in the results of the hop performance. The number of patients who were not able to hop 6 or 12 months after surgery may bias our results.

CONCLUSION

To conclude this study allowed to identify a progression of the knee function of an ACL-reconstructed population through its rehabilitation period and to set first references of those patients. Six months after surgery, the patients presented an insufficient isokinetic thigh muscle force and hop performance compared to the contralateral leg. This weakness of the operated leg should influence the decision of the adequate time of return to sport. In the future, standardized references considering gender, age, preinjury level of practice and associated injuries are needed in order to have specific references and to find the most adapted management for each patient profile.

REFERENCES

[1] P.A. Renstrom, Eight clinical conundrums relating to anterior cruciate ligament (ACL) injury in sport: recent evidence and a personal reflection, British journal of sports medicine, fr47 (2013) 367-372.

[2] L.P. Granan, M. Forssblad, M. Lind, L. Engebretsen, The Scandinavian ACL registries 2004-2007: baseline epidemiology, Acta Orthop, 80 (2009) 563-567.

[3] O.E. Olsen, G. Myklebust, L. Engebretsen, R. Bahr, Injury mechanisms for anterior cruciate ligament injuries in team handball: a systematic video analysis, Am J Sports Med, 32 (2004) 1002-1012.

[4] T. Krosshaug, A. Nakamae, B.P. Boden, L. Engebretsen, G. Smith, J.R. Slauterbeck, T.E. Hewett, R. Bahr, Mechanisms of anterior cruciate ligament injury in basketball: video analysis of 39 cases, Am J Sports Med, 35 (2007) 359-367.
[5] R.B. Frobell, L.S. Lohmander, H.P. Roos, Acute rotational trauma to the knee: poor agreement between clinical assessment and magnetic resonance imaging findings, Scandinavian journal of medicine & science in sports, 17 (2007) 109-114.
[6] R. Seil, C. Mouton, A. Lion, C. Nührenbörger, D. Pape, D. Theisen, There is no such thing like a single ACL injury: profiles of ACL-injured patients, Orthopaedics & traumatology, surgery & research : OTSR, (2015).
[7] C.W. Fuller, R. Bahr, R.W. Dick, W.H. Meeuwisse, A framework for recording recurrences, reinjuries, and exacerbations in injury surveillance, Clin J Sport Med, 17 (2007) 197-200.
[8] C.L. Ardern, K.E. Webster, N.F. Taylor, J.A. Feller, Return to sport following anterior cruciate ligament reconstruction surgery: a systematic review and meta-analysis of the state of play, British journal of sports medicine, 45 (2011) 596-606.
[9] L. Salmon, V. Russell, T. Musgrove, L. Pinczewski, K. Refshauge, Incidence and risk factors for graft rupture and contralateral rupture after anterior cruciate ligament reconstruction, Arthroscopy, 21 (2005) 948-957.
[10] N. Pujol, M.P. Blanchi, P. Chambat, The incidence of anterior cruciate ligament injuries among competitive Alpine skiers: a 25-year investigation, Am J Sports Med, 35 (2007) 1070-1074.
[11] G.B. Maletis, M.C. Inacio, T.T. Funahashi, Analysis of 16,192 anterior cruciate ligament reconstructions from a community-based registry, Am J Sports Med, 41 (2013) 2090-2098.
[12] L. Engebretsen, M. Forssblad, M. Lind, Why registries analysing cruciate ligament surgery are important, British journal of sports medicine, 49 (2015) 636-638.
[13] E.M. Roos, H.P. Roos, L.S. Lohmander, C. Ekdahl, B.D. Beynnon, Knee Injury and Osteoarthritis Outcome Score (KOOS)--development of a self-administered outcome measure, The Journal of orthopaedic and sports physical therapy, 28 (1998) 88-96.
[14] L.D. Higgins, M.K. Taylor, D. Park, N. Ghodadra, M. Marchant, R. Pietrobon, C. Cook, Reliability and validity of the International Knee Documentation Committee (IKDC) Subjective Knee Form, Joint, bone, spine : revue du rhumatisme, 74 (2007) 594-599.
[15] R.W. Wright, A.K. Haas, J. Anderson, G. Calabrese, J. Cavanaugh, T.E. Hewett, D. Lorring, C. McKenzie, E. Preston, G. Williams, Anterior Cruciate Ligament Reconstruction Rehabilitation: MOON Guidelines, Sports health, 7 (2015) 239-243.
[16] B.D. Beynnon, R.J. Johnson, J.A. Abate, B.C. Fleming, C.E. Nichols, Treatment of anterior cruciate ligament injuries, part 2, Am J Sports Med, 33 (2005) 1751-1767.
[17] P.J. Plisky, P.P. Gorman, R.J. Butler, K.B. Kiesel, F.B. Underwood, B. Elkins, The reliability of an instrumented device for measuring components of the star excursion balance test, N Am J Sports Phys Ther, 4 (2009) 92-99.
[18] C. Mouton, R. Seil, T. Meyer, H. Agostinis, D. Theisen, Combined anterior and rotational laxity measurements allow characterizing personal knee laxity profiles in healthy individuals, Knee Surg Sports Traumatol Arthrosc, 23 (2015) 3571-3577.
[19] A. Gustavsson, C. Neeter, P. Thomee, K. Gravare Silbernagel, J. Augustsson, R. Thomee, J. Karlsson, A test battery for evaluating hop performance in patients with an ACL injury and patients who have undergone ACL reconstruction, Knee Surg Sports Traumatol Arthrosc, 14 (2006) 778-788.
[20] E. Ageberg, M. Forssblad, P. Herbertsson, E.M. Roos, Sex differences in patient-reported outcomes after anterior cruciate ligament reconstruction: data from the Swedish knee ligament register, Am J Sports Med, 38 (2010) 1334-1342.
[21] N. Desai, H. Bjornsson, K. Samuelsson, J. Karlsson, M. Forssblad, Outcomes after ACL reconstruction with focus on older patients: results from The Swedish National Anterior Cruciate Ligament Register, Knee Surg Sports Traumatol Arthrosc, 22 (2014) 379-386.
[22] C.L. Ardern, K.E. Webster, N.F. Taylor, J.A. Feller, Return to the preinjury level of competitive sport after anterior cruciate ligament reconstruction surgery: two-thirds of patients have not returned by 12 months after surgery, Am J Sports Med, 39 (2011) 538-543.

SHOULDER INJURY PREVENTION PROGRAM IN HANDBALL

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SUMMARY: The aim of this study is to present an injury prevention program for shoulder, that was implemented to CSM Bucharest women handball team during the season 2014-2015, in order to minimize the risks of common injuries in handball, as the shoulder ones. We mention that even if in the past, four players went through difficult shoulder surgeries, during this season, none of the players from CSM Bucharest team haven't experienced serious shoulder problems.

Keywords: handball, injury, shoulder, prevention.

INTRODUCTION

Handball is a physical game characterized by complexity, due to the requirements imposed. A combination of speed, power, agility, strength and coordination as well as mental and technical preparation is needed by handball players to sustain all the accelerations, deceleration, changes of direction, turns around, jumps, or throws. The number of body contacts is higher than ever, and because of this, the domain specialists consider handball a very traumatic sport (Vlak, T., Pivalica, D., 2004), which causes a lot of short or long terms injuries. Only football (45.8%) surpassed handball (15,3%) in top sports with most injuries (Luig, P., Henke, T., 2009).

According to recent researches, shoulder injury is considered one of the most predominant injuries in the game of handball. Understanding the injury mechanism is very important, in order to prevent them. Taking into consideration that over a season, a handball player performs thousands of throws where the shoulder has the major role, overuse may appear and can lead to unwanted injuries. Also, internal rotator and external rotator muscles imbalances are highly associated with a risk of shoulder injury (Wang, H., K., Cochrane, T., 2001). These are the reasons why we share other specialists' idea (Bahr, R., Krosshaug, T., 2005) that injury prevention should be included as a constitutive part in the training program.

The aim of this study is to present an injury prevention program for shoulder, that was implemented to CSM Bucharest women handball team during the season 2014-2015, in order to minimize the risks of common injuries in handball, as the shoulder ones.

METHODS

Participants

The subjects included in our research are the female handball players from the club CSM Bucharest, Romania, counting a total of 19 players (age: 29.6 ± 4.3; height: 176.3 ± 5.9; weight: 69.7 ± 7.7). To have a clear medical situation, individual charts were filled, after questioning each player about their medical history. Regarding the current research theme, inside of the team, a number of 4 players went earlier in their professional careers, through difficult shoulder surgeries on their dominant arm. The latest surgery was noted for the year 2013. More than that, one of the players suffered two interventions on the same (dominant) shoulder.

Tests

Two tests were used in order to discover the muscle imbalances and dysfunctionality. To diagnose the functionality of internal rotator (IR) and external rotator (ER) muscles, we examined the glen humeral internal and external range of motion on both dominant and nondominant shoulder. The passive range of glenohumeral IR and ER was measured using the protocol described by Wilk, K., E. et al (2011).

Description of the test: at scapular plane, in a seated position, with 90° between their forearm and humerus, with their forearm perpendicular to the floor, subjects were instructed to slowly reach the end-range of humeral external rotation followed by end-range of internal rotation. The end-range (shoulder external and internal rotation) was self-determined by the subject (subject was not able to go further on the movement) or when the examiner observed trunk motion. A goniometer was used to measure the degrees of rotations from the zero point (0°) to their end-range. The start position or the zero point (0°) was defined as the point when the subject's forearm was perpendicular to the floor.

The second test used was Overhead squat test (upper body), to understand the players' faulty movement patterns, evaluating upper body strength, flexibility and neuromuscular control. Description of the test: The player starts from a standing position, with arms raised overhead, elbows fully extended and has to perform 5 squats for each position of the person examining (frontal view, lateral view, behind view). The player movements during the test will offer answers about the existing muscular imbalances.

At the beginning of the preparatory phase of the season 2014-2015 (10.07.2014), all the players were tested in order to get the current situation about their level of the most important physical, functional and anthropometric parameters. The two tests described were also applied. According to the results obtained, a training program was conducted, taking also into consideration the characteristics of each preparation phase. The tests were applied again after a 4 months period, during which there were used the training programs proposed through the current research.

Statistical methods
In order to analyse the obtained results, basic statistical-mathematical calculations were applied: mean, standard deviation, variance. Also, to analyse the differences recorded between the initial and final testing, T test for related samples was used.

INSTRUCTION CONTENT (DEVELOPMENT)
The program implemented for preventing injuries of shoulder was used in different periods of the training. Some of the means were included in the warm up section. Others were used at the end of the training (stretching). The third category includes exercises performed in the gym, using additional weights, different materials as TRX, fitball, vibrating stick, and elastic band.

Figure 1. *Warm up exercises*
Warm up exercises were included in the weekly schedule three times in the preseason and two times during the competitional period. For exercises 3, 4 and 5, the number of repetitions varied from 8 to 10 for each side, with a slow tempo and controlled movements. For exercises 1 and 2 (the plank position), the duration was 60 – 90 sec. for the frontal position and 30 – 45 sec. for the lateral one.

Figure 2. *Exercises using additional weights and different materials*

Additional weights exercises

The exercises presented in Figure 2 (left) were applied once a week during the whole period of the research. The players had to perform 3 series of 10 reps for exercises 1 and 3. The second exercise was repeated 3 times of 16 reps, alternating each foot forward. For the 4th exercise, 3 series of 8 reps were performed in both directions.

Exercises using different materials

The exercises presented in Figure 2 (right) were also applied once a week during the whole period of the research. Exercises 2 and 3 were performed at the end of the gym session, 3 times of 12-15 reps, using a slow tempo and controlled movement. For exercises 4 and 5, the players had to perform 3 series of 10 reps. The difficulty of these exercises were increased by positioning the feet closer to the anchor point of the TRX. The increase was allowed only if the exercises were performed with a good technique. The duration of the 6th exercise was 10 seconds and was repeated 3 times. The players had to maintain the wrists aligned with the shoulders, with their thumbs slightly turned towards the floor. A more powerful impulse to the vibrating stick was allowed only if the exercise was performed with good technique.

Figure 3. *Stretching exercises*

Stretching exercises were performed at the end of all the trainings programed in the research period. Each position should be maintained for 20 seconds. The players who obtained weak results in the mobility test had to repeat the positions dedicated to the joints that needed improvement.

RESULTS

Table 1. *Results for glenohumeral internal and external rotation range of motion*

	Testing	X	M	S	Cv	T value	p
ER left	Initial	85.9	91	7.9	9.3%	4.205	0.001
	Final	91.2	92	4.8	5.4%		
ER right	Initial	88.2	90	5.9	6.7%	4.259	0.000
	Final	91.5	92	3.8	4.1%		
IR left	Initial	65.7	70	9.3	14.2%	3.353	0.004
	Final	69.9	72	5.9	8.6%		
IR right	Initial	63.2	70	10.1	16%	3.958	0.001
	Final	67.8	72	7.3	10.8%		

As shown in Table 1, a progress could be registered for both shoulders, internal and external rotation in terms of mobility. The differences between initial and final testing are statistically significant for all the cases presented, according to p values ($p < 0.05$). The training programs used through the current research regarding the upper body were, as demonstrated, efficient and led to an increase of the joints mobility.

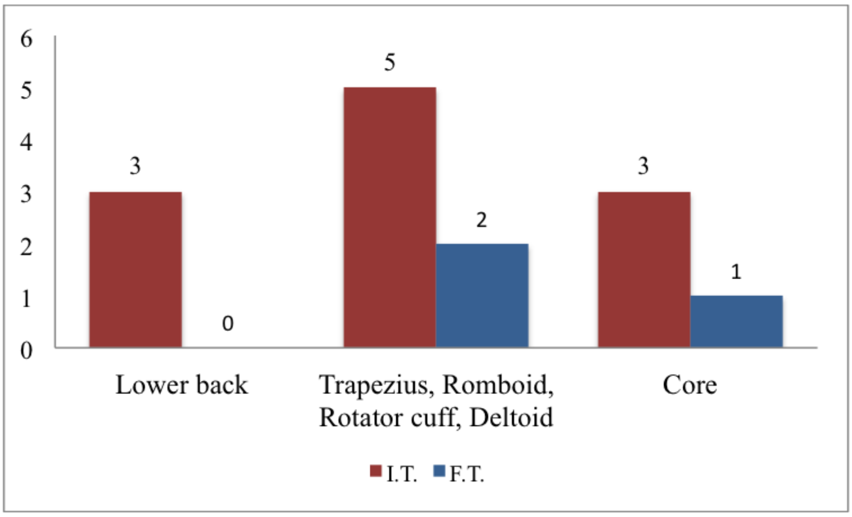

Figure 4. *Evolution of the upper body muscular imbalances*

At the beginning of the preparation period, when the initial testing was applied, 3 players showed muscular imbalances in the lower back, 5 players had problems with trapezius, rhomboid, rotator cuff and deltoid muscles, while another 3 players presented a weak core. After applying the training programs during the research period, as it can be also observed in Figure 4, at the number of the players still having problems decreased in all three cases. The lower back problems were fully resolved.

CONCLUSION

As the main focus of each athlete is to maximize the performances, the own limits are often reached and breached, with huge amounts of intense effort. In order to prevent injuries that may occur, preventive measures should be integrated into the daily sport-specific performance intensification programs. During 2014-2015 season, none of the players from CSM Bucharest team have experienced serious shoulder problems, even if in the past 4 of these players went through difficult shoulder surgeries. This is one of the main reasons why we believe in the efficiency of the programs applied. The results obtained at the Overhead squat test and Glenohumeral internal and external rotation range of motion come also as a confirmation of the efficiency of the shoulder prevention training programs. Injuries cannot be fully avoided if all the preventive measures are taken. But even a small reduction of the injuries can lead to an optimization inside of the professional life of a handball team, meaning better chances in reaching the highest performances.

REFERENCES

Vlak, T., Pivalica, D.: Handball: the beauty or the beast. Croat Med J 2004; 45: 526-530

Luig, P., Henke, T.: Injury prevention in handball, Science and Analytical Expertise in Handball (Scientific and Practical Approaches), Chapter: Humanities, European Handball Federation Publisher 2009, pp. 84-88

Bahr, R., Krosshaug, T.: Understanding injury mechanisms: a key component of preventing injuries in handball, Br J Sports Med 2005, No.39, p.324-329

Wang, H., K., Cochrane, T. Mobility impairment, muscle imbalance, muscle weakness, scapular asymmetry and shoulder injury in elite volleyball athletes. J Sports Med Phys Fitness 2001; 41: 403–410

Wilk, K., E., Macrina, L., C., Fleisig, G., S., Porterfield, R., Simpson, C., D., Harker, P., Paparesta, N., Andrews, J., R. Correlation of glenohumeral internal rotation deficit and total rotation motion to shoulder injuries in professional baseball pitchers. Am J Sports Med 2011: 39:329-335.

SHOULDER STRESS IN DIFFERENT TEAM-HANDBALL THROWING TECHNIQUES

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SUMMARY

The aim of the study was to measure upper body kinematics in different team-handball throwing techniques, and to compare the stress in the shoulder with the stress in other upper body joints. Differences in the throwing techniques were found in the ball velocity and angular rotation velocities, whereas the highest angular velocity was found in the shoulder internal rotation. To prevent injuries in the shoulder, it is essential to strengthen the shoulder rotators.

Keywords: Upper body kinematics, proximal-to-distal sequencing, ball velocity, elite male players

INTRODUCTION

Team-handball is an Olympic sport game that is characterized by intense dynamic movements and numerous physical confrontations during the game. To increase performance in team-handball, it is important to optimize individual and team performance (Wagner et al. 2014) and to prevent injuries. Langevoort et al. (2007) investigated team-handball injuries during major international tournaments and found 108 injuries per 1000 player hours in elite male and female players. Most of these injuries incurred due to the contact with other players. The injuries affected most frequently the lower extremity (42%) while upper extremity injuries including the shoulder were also frequently diagnosed (18%). Around a quarter of the injuries (23%) resulted in an absence of training and competition for up to one week (Langevoort et al. 2007). Whereas acute injuries were mainly found in the lower extremities, overuse symptoms like current or previous pain was frequently found in the shoulder.

Myklebust et al. (2013) investigated shoulder pain among elite female team-handball players and found that 36% of the players reported shoulder pain on the test day, and 22% reported previously occurring shoulder pain. Similar results were found by Seil et al. (1998) who identified the shoulder as the most common site for overuse symptoms in male senior team-handball players. Stress in the shoulder is due to physical contact during game and competition as well as numerous repetitions of high performance throws. Therefore, awareness of the stress in the shoulder during team-handball throwing is important to understand and prevent shoulder injuries. The throwing movement in team-handball is characterized by an optimal proximal-to-distal sequencing from the lower body to the throwing arm (Van den Tillaar & Ettema 2009; Wagner et al. 2012) whereas the shoulder internal rotation angular velocity is the main factor determining throwing performance (Van den Tillaar & Ettema 2007; Wagner et al. 2010). However, a comprehensive study comparing performance in different throwing techniques, especially stress in the shoulder is lacking.

Consequently, the aim of the study was (1) to measure 3D-kinematics in different team-handball throwing techniques, (2) to describe different throwing techniques via the upper body kinematics, and (3) to compare the stress in the shoulder with the stress in other upper body joints. We hypothesized to find significant differences in the upper body kinematics between the different throwing techniques and a higher stress in the shoulder compared to the other upper body joints.

METHODS

Fourteen male elite team-handball players (age: 22.5±3.7 yrs; height: 1.87±0.06 m; body mass: 84.4±10.5 kg; training experience: 10.3±3.6 yrs), playing in the first and second Austrian Handball, first German and Spanish Handball Leagues participated in the present study. All participants were physically healthy, in good physical condition and reported no injuries during the time of the study. The study was approved by the local ethics committee. Written informed consent was obtained from all participants before testing.

After a general and a team-handball specific warm up of 20 min, the participants have to perform 10 valid (for each throwing technique) standing throws without run-up, standing throws with run-up with the throwing arm above and beside the trunk, vertical jump throws, and pivot throws (jump throw take off with both legs after turning). The ranking order of the five throwing techniques was randomized for each participant. After five valid throws the participants changed the throwing technique and repeated the same procedure a second time to ensure that fatigue did not influence the results. To measure throwing performance we used a square of 0.5×0.5 m at about eye level (1.75 m high) and instructed the participants to throw the ball with a maximal ball velocity to the center of the target. Horizontal distance between the ball and the target at ball release was about 8 m, except for the standing and pivot throw (about 7 m), that enables similar distances to the goal as in competition. A throw was valid if the ball did not deviate from the center of the target in the horizontal and vertical directions by more than 0.5 m, and if all data were recorded without failure. This was conducted until 10 valid throws for each of the five throwing techniques for each participant were accomplished and recorded. To ascertain that only the best throws of the five throwing technique of every participant were calculated, the six throws with the greatest ball velocity for every participant were used for statistical analysis.

The experimental set-up consisted of an eight camera Vicon MX13 motion capture system (Vicon Peak, Oxford, UK), at 250 Hz. For kinematic analysis, 39 reflective marker of 14 mm diameter were affixed to specific anatomical landmarks (Plug-In Gait Marker Set, Vicon Peak, Oxford, UK) for every participant. Three-dimensional (3D) trajectories of the 39 markers were analyzed utilizing Nexus software (Nexus 1.3, Vicon, Oxford, UK) and filtered with a Woltring filter. To calculate the joint positions, a 3D-model (Plug-In Gait Model, Vicon Peak, Oxford, UK) was used (Davis et al. 1991), dividing the body into upper and lower body models. The model used was identical to that of Wagner et al. (2010) who analyzed the jump throw in team-handball.

For joint angle calculation we used the same method as described previously in detail by Wagner et al. (2010). Joint angles were calculated by the relative orientation of the proximal and distal segments. The shoulder internal-external rotation angle was defined as the rotation of the humerus along the longitudinal axis of the humerus. A positive value corresponds to internal shoulder rotation. Pelvis/trunk rotation angles were calculated between the sagittal axis of the pelvis/trunk and those of the sagittal axis of the measuring field and the trunk side tilt between the projected transverse trunk axis and the transverse axis of the measuring field. Trunk side tilt was defined positive for a side tilt to the throwing arm side and negative for a side tilt to the throwing arm opposite side.

Angular velocities were calculated using the 5-point central differential method (Van den Tillaar & Ettema 2003). Ball release point and ball velocity were determined as described previously in detail by Wagner et al. (2010). For a detailed discussion of the results, we separated the throwing movements into three different phases, one after ball release (follow through phase) and two phases before ball release (cocking and acceleration phase). We termed the acceleration phase as the time lag between the moment when the angular acceleration of the trunk rotation became maximal to ball release. Cocking phase was defined from the beginning (400ms before ball release) to the beginning of acceleration phase, and follow through phase from ball release to the end (100ms after ball release). Proximal-to-distal sequence was defined by the time of occurrence of the maximal joint angular velocities (Figure 1). All timing variables were measured relative to ball release. To determine the ball release point, the distance between the center of the ball and the finger of the throwing arm was calculated. This distance increased abruptly at ball release (Van den Tillaar & Ettema 2007; Wagner et al. 2010).

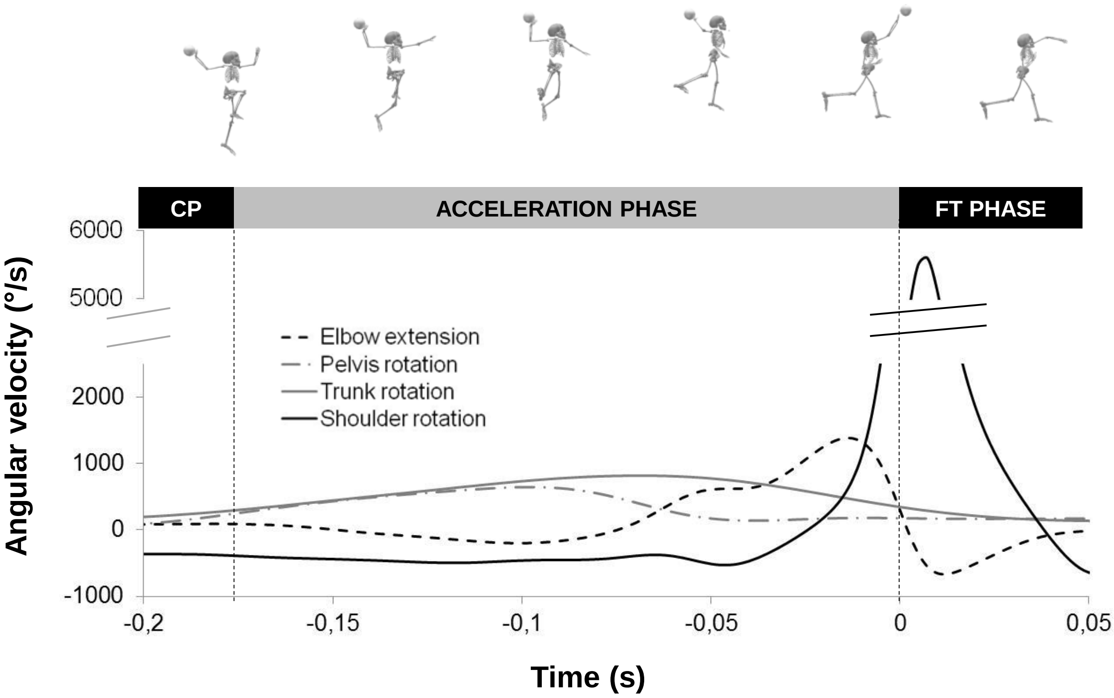

Figure 1. *Example of pelvis rotation, trunk rotation, elbow extension, and shoulder internal rotation angular velocity in the team-handball jump throw*

Statistical analysis was conducted via SPSS ver. 20.0 (SPSS Inc., Chicago, IL) software. Means and standard deviations of the variables were calculated for descriptive statistics. A general linear model with repeated measures, analysis of variance and the Bonferroni post-hoc test was used to calculate the statistically relevant differences between the five throwing techniques (within subject factors).

RESULTS

Mean values ± standard deviations of the ball velocity, angles, angular velocities and their timing in the different throwing techniques and significant differences between the different throwing techniques are depicted in Table 1. Significant differences between the five throwing techniques were found in the ball velocity ($p < .001$, $\eta^2 = .42$, $\beta = 1.00$), pelvis ($p < .001$, $\eta^2 = .47$, $\beta = 1.00$) and trunk rotation angular velocity ($p < .001$, $\eta^2 = .35$, $\beta = 1.00$), trunk ($p < .001$, $\eta^2 = .76$, $\beta = 1.00$) and arm tilt ($p < .01$, $\eta^2 = .21$, $\beta = .91$). An example of the pelvis rotation, trunk rotation, elbow extension, and shoulder internal rotation angular velocity in the jump throw to describe the proximal-to-distal sequencing is shown in Figure 1.

Table 1. *Mean values ± standard deviations of the ball velocity, pelvis, trunk and internal shoulder rotation angular velocity, elbow extension angular velocity, timing relative to ball release, trunk tilt (in direction to the throwing arm) as well as throwing arm tilt*

	standing	throwing arm above	throwing arm beside	jump	pivot	*p*-value
ball velocity (m/s)	22.3±1.2	23.9±1.2	22.6±1.6	21.9±1.6	20.4±1.2	< .001[adfgij]
pelvis velocity (°/s)	590±70	610±90	590±160	440±110	370±80	< .001[cdfghi]
trunk velocity (°/s)	800±60	830±80	810±160	730±80	640±60	< .001[dgi]
shoulder vel. (°/s)	5700±1050	5630±1260	5150±1400	4920±950	4730±910	*n.s.*
elbow vel. (°/s)	1670±280	1700±290	1580±340	1630±220	1420±650	*n.s.*
pelvis timing (s)	-0.11±0.02	-0.11±0.03	-0.11±0.03	-0.12±0.03	-0.13±0.02	*n.s.*
trunk timing (s)	-0.08±0.02	-0.08±0.02	-0.09±0.02	-0.09±0.02	-0.10±0.02	*n.s.*
shoulder timing (s)	0.00±0.00	0.00±0.01	0.01±0.01	0.00±0.00	0.00±0.00	*n.s.*
elbow timing (s)	-0.01±0.00	-0.01±0.00	-0.01±0.01	-0.02±0.01	-0.01±0.01	*n.s.*
trunk tilt (°)	-19±7	-19±6	7±9	-27±5	-24±5	< .001[bcefhi]
arm tilt (°)	100±7	102±8	95±7	105±7	105±8	< .01[hi]

Significant difference between standing and throwing arm above [a], standing and throwing arm beside [b], standing and jump [c], standing and pivot [d], throwing arm above and beside [e], throwing arm above and jump [f], throwing arm above and pivot [g], throwing arm beside and jump [h], throwing arm beside and pivot [i], jump and pivot throw [j]

DISCUSSION

As expected, all analyzed throwing techniques are characterized by a clear proximal-to-distal sequencing from the lower body to the throwing arm. Due to the movements of the lower body (lead leg braces the body in the standing throws vs. opposed leg movements during flight in the jump throws) maximal pelvis rotation velocity occurred 110-130ms before ball release, followed by the trunk rotation, elbow extension and shoulder internal rotation (Table 1). Similar to previous studies, the maximal internal rotation angular velocity occurred immediately after ball release (2-7ms) that lead to a very high shoulder rotation velocity at ball release and therefor to a high ball velocity.

The standing throw with run-up with the throwing arm above the trunk was the throwing technique with the highest ball velocity. This is due to the optimal transfer of momentum from the lower, over the upper body and throwing arm to the ball. As shown in Table 1, a higher pelvis rotation lead to a higher trunk rotation, elbow extension and shoulder rotation. The difference in ball velocity between this throwing technique and the standing throw is caused by the additional velocity due to the run-up. In the jump throws (jump and pivot throw) the missing ground contact during the flight lead to a reduced pelvis and trunk rotation and subsequently to a reduced ball velocity. In the standing throw with run-up with the throwing arm beside the trunk, the different trunk and throwing arm position at ball release (Table 1), prevent an optimal transfer from the trunk to the throwing arm and lead to a reduced elbow extension and shoulder rotation velocity and subsequently a reduced ball velocity.

Comparing the velocities in the different joints, the angular rotation velocity in the shoulder joint is the highest velocity in all joints of the human body. In our study, the highest shoulder rotation velocity was around 7000°/s that is in compliance with other studies in team-handball and baseball (Fleisig et al. 1999; Wagner & Müller 2008). To prevent acute injuries or overuse symptoms in the shoulder, it is essential to strengthen the shoulder rotator muscles and tendons by implementing special training programs and to alert all team-handball players and referees that catching the throwing arm during throwing, especially from the side or from behind is absolutely prohibited. Adjustments of the rules associated with these types of infractions have been adopted by the international and national team-handball federations in the last years.

CONCLUSION

In conclusion, we found differences in the ball velocity and angular rotation velocities between different throwing techniques, whereas the highest angular velocity was found in the shoulder internal rotation. To prevent injuries in the shoulder, it is essential to strengthen the shoulder rotators.

REFERENCES

Davis RB, Ounpuu S, Tyburski D, Gage JR. A gait analysis data collection and reduction technique. *Human Movement Science*. 1991: **10**: 575-587.

Fleisig GS, Barrentine SW, Zheng N, Escamilla RF, Andrews JR. Kinematic and kinetic comparison of baseball pitching among various levels of development. *Journal of Biomechanics*. 1999: **32**: 1371-1375.

Langevoort G, Myklebust G, Dvorak J, Junge A. Handball injuries during major international tournaments. *Scandinavian Journal of Medicine & Science in Sports*. 2007: **17**: 400-407.

Myklebust G, Hasslan L, Bahr R, Steffen K. High prevalence of shoulder pain among elite Norwegian female handball players. *Scandinavian Journal of Medicine & Science in Sports*. 2013: **23**: 288-294.

Seil R, Rupp S, Tempelhof S, Kohn D. Sports injuries in team handball - A one-year prospective study of sixteen men's senior teams of a superior nonprofessional level. *American Journal of Sports Medicine*. 1998: **26**: 681-687.

Van den Tillaar R, Ettema G. Instructions emphasizing velocity, accuracy, or both in performance and kinematics of overarm throwing by experienced team handball players. *Perceptual and Motor Skills*. 2003: **97**: 731-742.

Van den Tillaar R, Ettema G. A three-dimensional analysis of overarm throwing in experienced handball players. *Journal of Applied Biomechanics*. 2007: **23**: 12-19.

Van den Tillaar R, Ettema G. Is there a proximal-to-distal sequence in overarm throwing in team handball? *Journal of Sports Sciences*. 2009: **27**: 949-955.

Wagner H, Buchecker M, von Duvillard SP, Müller E. Kinematic comparison of team-handball throwing with two different arm positions. *International Journal of Sports Physiology and Performance*. 2010: **5**: 469-483.

Wagner H, Buchecker M, von Duvillard SP, Müller E. Kinematic description of elite vs. low level players in team-handball jump throw. *Journal of Sport Science and Medicine*. 2010: **9**: 15-23.

Wagner H, Finkenzeller T, Würth S, von Duvillard SP. Individual and Team Performance in Team-Handball: A Review. *Journal of Sports and Medicine*. 2014: **13**: 808-816.

Wagner H, Müller E. The effects of differential and variable training on the quality parameters of a handball throw. *Sports Biomechanics*. 2008: **7**: 54-71.

Wagner H, Pfusterschmied J, Von Duvillard SP, Muller E. Skill-dependent proximal-to-distal sequence in team-handball throwing. *Journal of Sport Science*. 2012: **30**: 21-29.

INJURIES ON THE DIFFERENT PLAYING POSITIONS IN TEAM HANDBALL

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SUMMARY

There are individual demands on the different playing positions in team handball, possibly implying different kinds of injuries on the positions regarding injury rate, type and location. Considering the position-specific differences concerning the sustained injuries, position-specific training should be applied in order to make use of the full potential of all players and to guarantee optimal injury prevention on all positions. To clarify matters, the available literature on handball-injuries on the positions has to be summarized to provide position-specific injury-profiles which can be used to optimize training processes. Also, gender-related differences have to be taken into account. The positions show individual injury-topographies and position-specific charateristic injuries. While position-unspecific injuries occur which are common for all positions, there additionally are different types and localizations of injury per position. To prevent injuries and make the most efficient use of all players' potential, position-specific prevention training programmes have to be developed and applied. The effects of position-specific training on injury prevention have to be researched further for both female and male players on all positions.

Keywords: handball, injuries, positions, male, female

INTRODUCTION

There are individual demands on the different playing positions in team handball, which lead to different kinds of injuries on the positions regarding injury rate, type, severity and topography. Position-specific training should be applied in order to make use of the full potential of all players and to guarantee optimal injury prevention on all positions. Here, the available literature on handball-injuries on the positions has to be summarized to provide facilitating optimization of specific training, taking gender-related differences into account. Luig & Henke (2011) assessed the injury distribution in male and female athletes using data from 8520 players between 14 and 45 years, discovering gender-related differences (Fig. 1). There are differences regarding injuries and game-demands of female and male athletes (Foretić, Rogulj, Burger & Raković, 2011; Marczinka, 2011; Michalsik & Aargaard, 2015; Platen & Manchado Lopez, 2007; Zapartidis Vareltzis, Gouvali & Kororos, 2009).

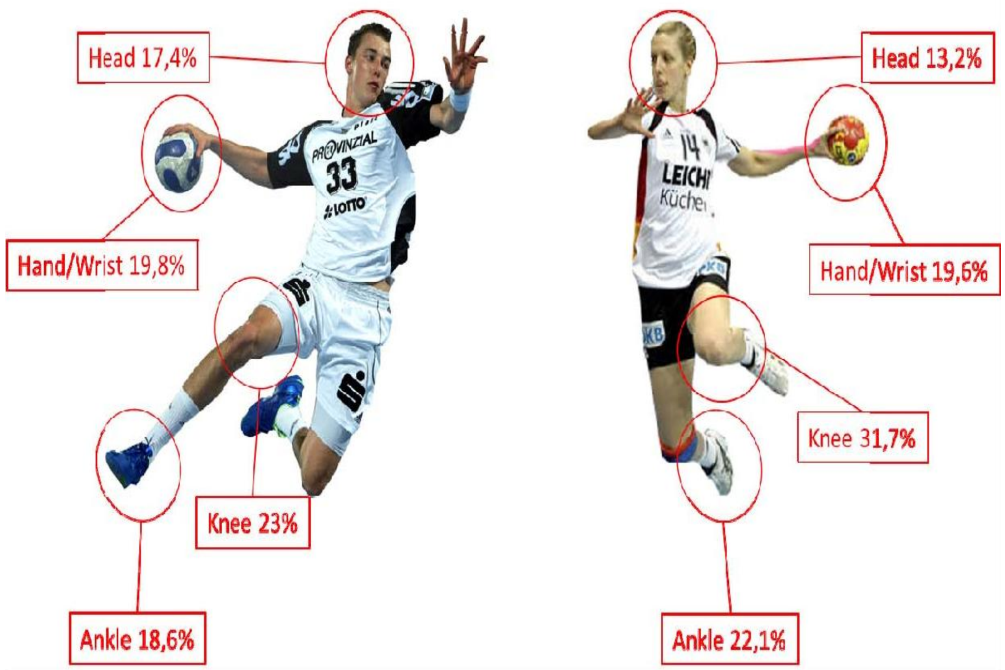

Fig. 1: *Gender-specific injury topography (Luig & Henke, 2011).*

METHODS

Databases (Scopus, google scholar) have been consulted using the terms “handball, injury, positions”. Articles were scanned for information on the position with the highest injury-risk, the injury topography on the positions, characteristic injuries for the positions, injury-severity and injury topography separate for female and male players. The collected data were mediated in a table.

RESULTS

Backplayers sustain more injuries than players on the pivot-position, followed by wingplayers and goalkeepers. However, most studies do not consider injuries per playing time when identifying high-risk-positions (Bere, Alonso, Wangensteen, Bakken, Eirale et al., 2015). Here, pivots and wing players are in the „lead“, followed by backplayers and goalkeepers. In most studies, half backs and centre backs are not considered separately, although the positions cover different demands (Weber, 2014) and do show slightly different injury rates (Tsigilis & Hatzimanouil, 2005). The positions show individual injury-topographies and position-specific characteristic injuries. For female goalkeepers and pivots, most injuries are light, but the percentage of severe injuries is higher than for wings and backs, while wings and backs sustain a higher percentage of medium severe injuries. While distorsions and resultingly strains and ruptures of ligaments are the most common types of injury, backs and wings also sustain muscle strains. Female and male players show different percentages regarding localization (Luig & Henke, 2011), risk for ACL-rupture (Olsen, Myklebust & Engebretsen, 2003) and game-demands. Table 1 shows the position-specific details concerning injury-location, risk for each position and characteristic injuries for every position separately for female and male players.

Tab. 1: *Position-specific injury profiles regarding female and male players, mediated from Bere et al. (2015), Froböse et al. (1996), Hatzimanouil et al. (2008), Langevoort et al. (2007), Mayer (2004), Olsen et al. (2003), Piry et al. (2011), Popovic et al. (2001; 2002), Seil et al. (1997), Tyrdal et al. (1998), Wedderkopp et al. (1997; 1999).*

		Male players
GK	Ranking of locations:	ankle, knee, hand / finger, elbow, trunk
	Risk-ranking positions:	5
	Characteristic injuries:	distorsions of the above named joints, stress on lig. coll. Med. of the elbow joint, rupture or strain of lig. talofibulare ant.
HB	Ranking of locations:	ankle, hand / finger, knee, shoulder, elbow / head, trunk
	Risk-ranking positions:	1
	Characteristic injuries:	distorsion of above named joints, rupture or strain of lig. talofibulare ant.
CB	Risk-ranking positions:	ankle, hand / finger, knee, shoulder, elbow / head, trunk
	Characteristic injuries:	2
	Ranking of locations:	distorsion of above named joints, rupture or strain of lig. talofibulare ant.
P	Characteristic injuries:	ankle, hand / finger, elbow, knee
	Ranking of locations:	4
	Risk-ranking positions:	distorsions, fractures, strains, rupture or strain of lig. talofibulare ant.
WP	Ranking of locations:	ankle, hand / finger, knee, shoulder, hip, elbow / trunk
	Risk-ranking positions:	3
	Characteristic injuries:	distorsion of above named joints, rupture or strain of lig. talofibulare anterior, fractures

		Female players
GK	Ranking of locations:	ankle, knee, elbow, finger, shoulder
	Risk-ranking positions:	4
	Characteristic injuries:	distorsions of the above named joints, rupture or strain of lig. talofibulare ant., stress on lig. coll. med. of the elbow joint
HB	Ranking of locations:	ankle, knee, finger, elbow, hand
	Risk-ranking positions:	1
	Characteristic injuries:	distorsions of the above named joints, rupture or strain of lig. talofibulare ant., ACL-rupture
CB	Risk-ranking positions:	ankle, knee, finger, elbow, hand
	Characteristic injuries:	2
	Ranking of locations:	distorsions of the above named joints, rupture or strain of lig. talofibulare ant., ACL-rupture
P	Characteristic injuries:	ankle, finger, knee / elbow / hand
	Ranking of locations:	3
	Risk-ranking positions:	distorsions of the above named joints, rupture or strain of lig. talofibulare ant.
WP	Ranking of locations:	ankle, knee, finger
	Risk-ranking positions:	3
	Characteristic injuries:	distorsions of the above named joints, rupture or strain of lig. talofibulare ant., ACL-rupture

GK = Goalkeeper, HB = Halfback, CB = Centre Back, P = Pivot, WP = Wingplayer; Lig. = Ligamentum, ant. = anterior, med. = mediale, Coll. = collaterale; ACL = anterior cruciate ligament.

DISCUSSION

It has to be said that both injury-reporting and intervention studies for players on the different positions have been few, not recent (thus not matching the current demands of the game, which is changing frequently due to technical and tactical developement, see Weber, 2014) and (regarding the topography) mostly restricted to female youth players, risk-rate only for male players or single injury types such as ankle sprains while not considering the playing position, although it is acknowledged that the positions have specific demands (Weber, 2014) and training reduces injury-risk (Wedderkopp, Kaltoft, Lundgaard, Rosendahl & Froberg , 1997; Hatzimanouil, Oxizoglou, Kanioglou, Manavis & Eleftherios 2008). Some injuries (like concussions in goalkeepers as reported by Radić, 2013) seem to be dangerously underreported and have to be surveyed accentuatedly.

CONCLUSION

While for players on all positions ruptures or strains of the ligamentum talofibulare anterior are the most common injury, there are still different types and localizations of injury per position and the positions show a differing risk for injury. For female back and wing players, ruptures of the ACL rank second, whereas for the pivots distorsions of the finger joints are in second place of sustained injuries. The goalkeepers occasionally suffer from stress on the ligamentum collaterale mediale of the elbow joint. Considering male players, there are less ACL-ruptures on the wing- and back positions, but rather distorsions of hands and fingers. Male pivots also sustain hand- and finger distorsions, followed by distorsions of the elbow, whereas male goalkeepers sustain distorsions of knee, hand/ fingers and elbow. To prevent injury-related absence and make the most efficient use of all players' potential, position-specific prevention training programmes should be developed and applied (perhaps using data of injuries during match-play at major international tournaments), including proprioceptive training for all positions, ACL-prevention training for female backs and wings, arm strength training especially for female goalkeepers and both female and male pivots, shoulder strength for all back players and hand / finger training for all positions. Some injuries which possibly cannot be prevented through training could be reduced by adjusting the rules of the game (for example concussions in goalkeepers).

REFERENCES

Bere, T., Alonso, J.-M., Wangensteen, A., Bakken, A., Eirale, C., Dijkstra, H. P., Ahmed, H., Bahr, R., Popovic, N. (2015). Injury and illness surveillance during the 24th Men's Handball World Championship 2015 in Qatar. *British Journal of Sports Medicine*, published online July 17, 2015.

Foretić, N., Rogulj, N., Srhoj, V., Buerger, A. & Rakovic, K. (2011). Differences in Situation Efficiency Parameters Between Top Men and Women Handball Teams. In EHF (Hrsg.), *EHF Scientific Conference 2011*. Haugsdorf: Hofer (S. 243 - 247).

Froböse, I., Knaak, A. K., Menke, W. (1996). Frequency and localisation of injuries in female handball players. *Deutsche Zeitschrift für Sportmedizin*, 1996.

Hatzimanouil, D., Oxizoglou, N., Kanioglou, A., Manavis, K., Eleftherios, S. (2008). Injuries in Athletes of National Handball Teams. *Physical Training Fitness for Combatives* (2008).

Langevoort, G., Myklebust, G., Dvorak, J., Junge, A. (2007). Handball injuries during major international Tournaments. *Scandinavian Journal of Medicine and Science in Sports* 17 (2007), 400-407.

Luig, P., Henke, T. (2011). Acute injuries in handball. EHF Scientific Conference 2011, Science and Analytical Expertise in Handball (Scientific and practical approaches), 18-19th of November 2011 in Vienna, Austria.

Marczinka, Z. (2011). What`s the difference? - Coaching female and male handball players. In EHF (Hrsg.), *EHF Scientific Conference 2011.* Haugsdorf: Hofer (S. 89 - 93).

Mayer, S. (2004). Verletzungen, Prävention und Rehabilitation im leistungsorientierten Damenhandball. *Leistungssport* 2 (2004), 40-45.

Michalsik L. B., Aargaard, P. (2015). Physical demands in elite team handball: Comparisons between male and female players. *Journal of Sports Medicine and Physical Fitness,* 55 (9), 878 – 891.

Olsen, O. E., Myklebust, G., Engebretsen, L. (2003). Relationship between floor type and risk of ACL injury in team handball. *Scandinavian Journal of Medicine and Science in Sports* 13 (2003), 299-304.

Platen, P., Manchado Lopez, C. (2007). Injuries in female sports with a special focus on handball. Sports Orthopaedics and Traumatology 23 (1), 19 – 26.

Piry, H., Fallahi, A., Kordi, R., Rajabi, R., Rahimi M., Yosefi, M. (2011). Handball Injuries in Elite Asian Players. World Applied Sciences Journal 14 (10), 1559 - 1565.

Popovic, N., Ferrara, M. A., Daenen, B., Georis, R., Lemaire, R. (2001). Imaging Overuse Injury of the Elbow in Professional Team Handball Players: A Bilateral Comparison Using Plain Films, Stress Radiography, Ultrasound an Magnetic Resonance Imaging. *International Journal of Sports Medicine* 22 (2001), 60-67.

Popovic, N., Lemaire, R. (2002). Hyperextension Trauma to the elbow: radiological and ultrasonic evaluation in handball goalkeepers. *British Journal of Sports Medicine* 36 (2002) 452-456.

Radić, V. (2013). Acute injuries in handball. Posted July 14th, 2013 on http://www.vanjaradic.fi/.

Seil, R., Rupp, S., Tempelhof, S., Kohn, D. (1997). Eine vergleichende, retrospektive Studie zwischen Regional- und Oberligamannschaften. *Sportverletzung, Sportschaden: Grundlagen - Prävention – Rehabilitation*, 2 (11), 58 - 62.

Tsigilis, N., Hatzimanouil, D. (2005). Injuries in handball: Examination of the risk factors. *European Journal of Sport Science*, 5 (3), 137 - 142.

Tyrdal, S., Olsen, B. (1998). Hyperextension trauma to the elbow joint induced through the distal ulna or the distal radius: Pathoanatomy and kinematics. *Scandinavian Journal of Medicine and Science in Sports* 8 (1998), 77-182.

Weber J. (2014). Untersuchung des Zusammenhanges zwischen Positionsspezialisierung und Leistung im Handballsport. Dissertation, Christian-Albrechts-University of Kiel.

Wedderkopp, N., Kaltoft, M., Lundgaard, B., Rosendahl, N., Froberg, K. (1997). Injuries in young female players in European team handball. *Scandinavian Journal of Medicine and Science in Sports* 7 (1997), 342-347.

Wedderkopp, N., Kaltoft, M., Lundgaard, B. (1999). Prevention of injuries in young female players in European team handball. A prospective intervention study. *Scandinavian Journal of Medicine & Science in Sports* 9 (1999), 41-47.

Zapartidis, I., Vareltzis, I., Gouvali, M. & Kororos, P. (2009 b). Physical fitness and anthropometric characteristics in different levels of young team handball players. *The Open Sports Sciences Journal,* 2, 22 - 28.

MORPHOLOGICAL CHARACTERISTICS OF ELITE FEMALE HANDBALL PLAYERS

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SUMMARY
The peculiarities of the physical development of female handball players are of great importance both for the biomedical control in various stages of their sports career and for choosing among various sporting disciplines. The physical development of the individual is basically measured through its morphological characteristics.

Keywords: *female handball players, physical development, biomedical control*

The peculiarities of the physical development of female handball players are of great importance both for the biomedical control in various stages of their sports career and for choosing among various sporting disciplines. The physical development of the individual is basically measured through its morphological characteristics.

This is particularly relevant for the morphological characteristics of women athletes as the female body is much more sensitive to the effects of different exercise than the male body. Combined with the fact that there is scarce research on the subject in Bulgaria, the latter has determined and focused the author's interest to research the physical status of elite female handball players (2, 5, 1). It is only F. Taborsky (2011) who has researched the anthropometric profiles and the somatic type, however with 20 year-old male handball players.

The purpose of this study is to identify morphological peculiarities of elite female Bulgarian handball players and compare those to athletes practicing other sports. Furthermore, it aims to determine morphological differences between players occupying different handball positions.

METHODOLOGY
The study is based on a research of 39 elite Bulgarian female handball players. 16 anthropometric indicators have been researched. The average age of the surveyed athletes is 22 years and their sporting experience is an average of 8 years. From the wide range of anthropological signs two groups have been purposefully selected:

1. The total body size, making it possible to define body type and proportionality – height, weight, length of lower limb (LLL), length of upper limb (LUL), stretch, stretch of fingers of the hand (length of the span), upper arm circumference, forearm circumference, hip circumference and shank circumference.
2. Morphological indicators of functional importance that characterize the relationship between the main body components -percentage of body fat (BF}, active body mass (ABM), absolute amount of muscle mass (AAMM), body mass index (BMI), arm muscle circumference (AMC) and muscular upper leg circumference (MTC).

The three indicators – percentage of BF, ABM and AAMM are calculated by means of regression equations in which data for standard weight and skin folds has been used (as per Parzhishkova);

- AMC and MTC are calculated using a formula based on the main circumference measures and the respective thicknesses of skin folds.
- BMI is an integral criterion determining your body mass and is calculated according to a standard formula, based on height- for- weight data. It has been adopted as such by the World Health Organization together with a framework of individual categories.

Metric variation data have been processed statistically. Comparative analyses have been carried out of data of elite female handball players and women athletes from other sporting disciplines as per P. Ignatov (National center "Sport and Health") (4) and data of female handball players elite of other sporting disciplines. The credibility of established differences is established at P <0.05.

ANALYSIS OF RESULTS

Bulgarian elite handball players are on the average 169.58cm tall and weigh 66.63 kg (Table. 1). They are significantly taller and heavier than the average 22-year-old Bulgarian woman – 161.8 cm and 61, 2 kg (P. Slunchev et al., 1992 – 4).

Comparative analysis between elite female handball players and other athletes is of particular interest. (Table. 2, H and Fig. 1). It refers to indicators included in P. Ignatov's study and includes data of female judo, biathlon, volleyball, aerobics, rowing and canoeing athletes. According to data concerning the major indicators of physical development of the individual, i.e. height and weight, the following differences stand out:

- Female handball players have been found to be significantly shorter than female volleyball players and significantly taller than other female athletes;
- Weight analysis shows that female handball players are significantly lighter than female volleyball players and heavier than biathlon and aerobic athletes within the gender.

The comparative analysis shows that there are differences in the morphological status of female representatives of those sports. These differences reveal a specificity visible in the comparative analysis of data on individual body components.

- Female handball players have a significantly greater percentages of body fat compared to aerobics whereas female representatives of the two water sports have a significantly bigger BM than handball players;
- ABM is a summary indicator of all non-fat body components (bones, muscles, internal organs, vessels). And since muscles are the main ecosensitive characteristics among these components, ABM is an indirect indicator of the degree of muscle development. The comparative analysis of the data for this indicator shows that female handball players have very well developed ABM which is credibly better represented than in judo, biathlon and aerobics female athletes. A reliably larger values of ABM compared to female handball players has been only observed with volleyball players. This fact is easily explained given the much higher height and greater weight of the latter.

AAMM data enable us to further refine the differences when compared to other athletes and show that female handball players have significantly greater amount of AAMM than biathlon, aerobics and canoeing athletes and significantly lower amount of AAMM only to volleyball players.

- When comparing the data of muscle circumference of the arms and upper legs, it is noteworthy that there are no significant difference for AMC. It is solely aerobics athletes who have a fairly smaller AMC. This result is logical having in mind the active exercise of the upper limbs in other sporting disciplines examined; solely aerobics athletes, who due to the nature of the sport do not make active use of their upper limbs, differ significantly from female handball players.
- Unlike muscle circumference of the upper limbs, however, female handball players have significantly larger MTC compared to almost all representatives of the other sporting disciplines, except for female volleyball players and rowers where little difference is observed.

Table 1: *Main anthropological data of elite female handball players*

	Height	Weight	LLL	LUL	Stretch of arms	Hand span	Circum-ference upper arm	Circum-ference of upper arm-muscle	Circum-ference upper arm-muscle	Circum-ference upper leg	Circum-ference upper leg-muscle	Circum-ference lower	% BW	ABM	AAMM	BMI	n	Elite f.handball players
X	169.53	66.63	94.65	72.42	172.71	21.98	25.82	22.33	24.08	57.19	54.12	36.42	15.78	55.97	28.68	23.14	39	Elite f. handball players
Sx	0.79	1.33	0.66	0.46	1.04	0.17	0.34	0.31	0.22	0.67	0.61	0.33	0.54	0.94	0.62	0.37	39	
S	4.93	8.32	4.13	2.87	6.49	1.05	2.09	1.91	1.39	4.16	3.82	2.05	3.37	5.85	3.88	2.29	39	
V	2.91	12.48	4.37	3.97	3.76	4.76	8.11	8.54	5.79	7.28	7.05	5.63	21.4	10.45	13.52	9.89	39	
X	171.1	68.52	95.52	72.28	175.18	22.47	26.5	23.35	24.25	57.33	55.70	36.58	15.13	57.80	30.20	22.79	6	Goal-keepers
Sx	1.42	4.74	0.59	0.81	1.75	0.44	1.13	0.94	0.63	2.37	2.27	1.00	1.65	3.08	1.98	1.28	6	
S	.47	11.62	1.44	1.99	4.29	1.09	2.76	2.29	1.54	5.71	5.56	2.46	4.04	7.54	4.85	3.15	6	
V	2.03	16.96	1.50	2.74	2.45	4.84	10.40	9.81	6.36	9.96	9.99	6.72	26.71	13.05	16.05	13.49	6	
X	166.31	64.63	91.88	71.23	168.94	21.54	25.50	21.80	23.62	57.06	53.81	36.12	16.44	53.89	27.36	23.31	17	LW, RW, P
Sx	1.19	2.16	1.13	0.69	1.65	0.25	0.51	0.45	0.33	0.96	0.86	0.60	0.60	1.60	0.94	0.60	17	
S	4.91	8.93	4.65	2.78	6.62	1.02	2.09	1.87	1.38	3.97	3.56	2.48	2.47	6.59	3.88	2.49	17	
V	2.95	13.81	5.06	3.91	3.92	4.73	8.20	8.58	5.82	6.95	6.62	6.88	15.05	12.23	14.17	10.70	17	
X	172.31	68.06	96.62	73.56	175.79	22.26	25.91	22.50	24.50	56.91	53.86	36.69	15.28	57.49	29.52	23.10	16	LC, RC, CB
Sx	0.86	1.52	0.84	0.72	1.25	0.23	0.47	0.43	0.32	0.98	0.86	0.34	1.00	0.89	0.71	0.45	16	
S	3.45	6.10	3.35	2.87	5.01	0.94	1.90	1.72	1.29	3.90	3.45	1.36	3.99	3.57	3.25	1.80	16	
V	2.00	8.96	3.47	3.91	2.85	4.21	7.33	7.65	5.27	6.86	6.40	3.72	26.13	6.21	11.01	7.86	16	

Table 2: *Comparative data with female athletes from other sporting disciplines*

	Height	weight	% BW	ABM	AAMM	AMC	MTC	n	Type of sport
x	169.53	66.63	15.76	55.97	28.68	22.33	54.12	39	handball
s	4.93	8.32	3.37	5.85	3.88	1.91	3.82		
x	163.30	64.10	15.80	53.80	27.60	23.70	52.10	44	judo
s	4.54	7.69	3.38	5.62	3.49	1.65	3.01		
x	163.50	56.60	15.90	47.60	23.50	21.40	49.10	15	biathlon
s	5.50	4.74	3.31	4.44	2.99	1.92	2.16		
x	183.70	71.80	15.10	60.80	30.60	21.80	53.20	70	volleyball
s	6.34	6.35	4.76	4.13	2.30	1.18	2.30		
x	163.30	54.30	11.50	48.00	23.30	20.90	48.00	35	aerobics
s	6.56	6.08	3.49	5.59	2.99	1.46	2.24		
x	174.00	70.30	18.60	57.30	28.80	22.20	53.60	32	rowing
s	6.37	7.55	2.87	6.37	3.64	1.20	2.89		
x	167.00	66.90	18.80	54.10	26.80	23.50	50.90	20	canoeing
s	4.59	6.32	3.92	3.65	2.19	1.40	2.29		

The second objective of this study has been to assess whether the physical activity in various positions in the handball game have specific impact on the morphological status of female handball players (Table 1, 4).

Table 3: *Credibility of the differences between elite female handball players and representatives of other sporting disciplines expressed through t-criterion*

Number	**indicators**	**Elite Female Handball Players**					
		handball	**judo**	**biathlon**	**volleyball**	**aerobics**	**rowing**
1	Height	7.06	5.36	12.90	5.98	2.00	3.20
2	weight	–	6.97	3.38	9.05	–	–
3	% BW	–	–	–	5.33	4.46	3.84
4	ABM	2.99	7.14	4.56	5.99	–	–
5	AAMM	–	6.22	2.82	6.34	2.34	–
6	AMC	–	–	–	4.06	–	–
7	MTC	3.42	6.87	–	8.50	4.82	–

Table 4

Number	***Indicators***	***Elite handball players***		
		Goalkeepers	***Goalkeepers***	***LW, RW, CW***
		LW, RW, CW	***LB, RB, CB***	***LB, RB, CB***
1	*Height*	*2.17*	–	*4.03*
2	*Weight*	–	–	–
3	*Length of lower limb (LLL)*	–	–	*3.34*
4	*Length of upper limb(LUL)*	–	–	*2.37*
5	*Stretch of arms*	*2.14*	–	*3.33*
6	*Length of hand span*	–	–	*2.09*
7	*Circumference of upper arms*	–	–	–
8	*Circumference of lower arms*	–	–	*1.90*
9	*Circumference lower leg*	–	–	–
10	*Upper leg circumference*	–	–	–
11	% BW	–	–	–
12	ABM	–	–	*1.93*
13	AAMM	–	–	–
14	AMC	–	–	–
15	BMI	–	–	–
16	MTC	–	–	–

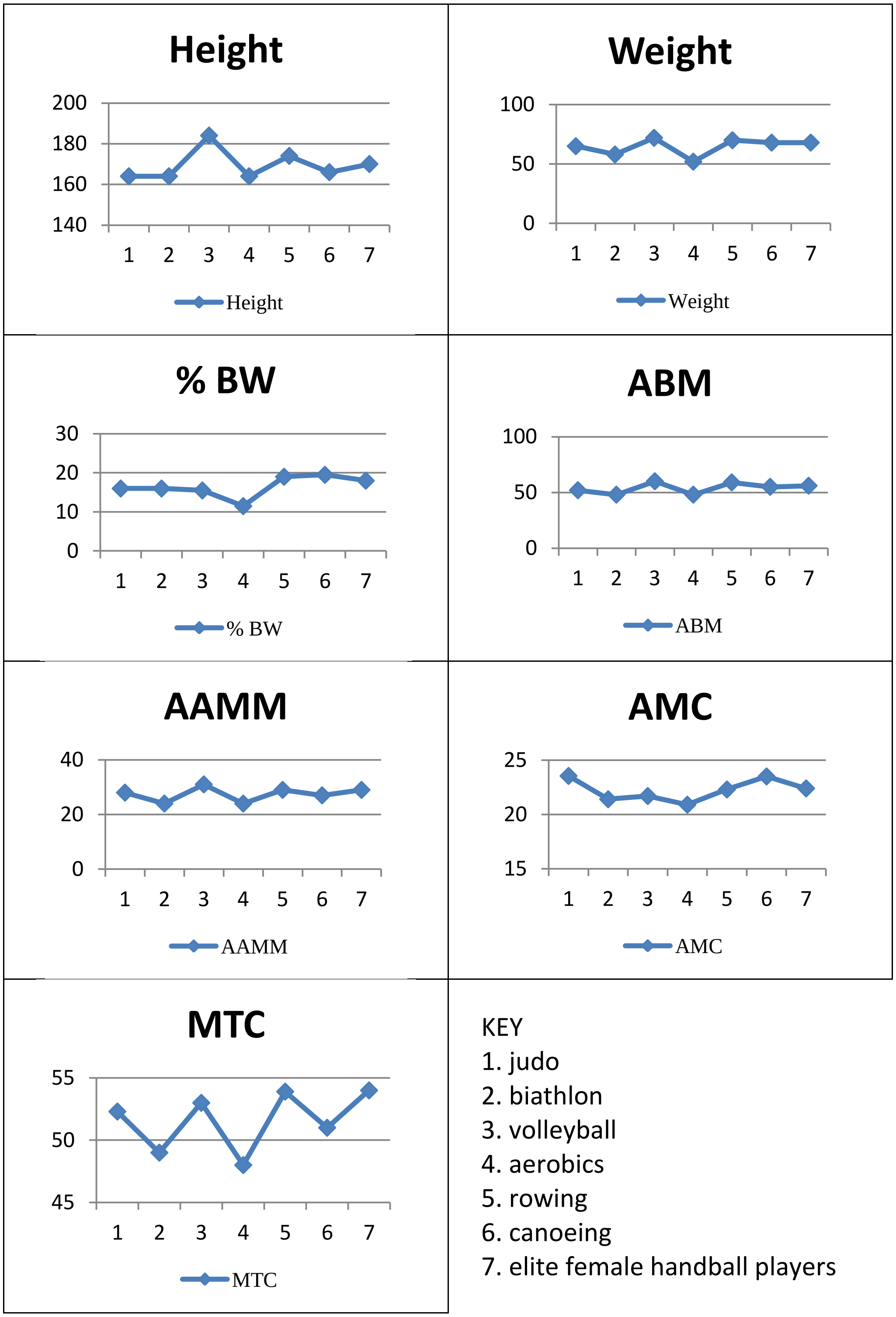

Fig 1

An overview of metric data and data of credible intergroup differences reveals a similarity in the morphological status of goal keepers and LB, RB and CB.

None of the intergroup comparisons between demonstrates statistically significant differences. Female handball players who play as LW, RW and P have a relatively more specific morphological type, which is characterized by a smaller size for almost all examined indicators.

There is a more pronounce difference between LB, RB and CB on the one hand and LW, RW and P on the other hand, as evidenced by a significantly large number of reliable intergroup differences. LW, RW and P have significantly smaller body dimensions, i.e. height, length of limbs, stretch, length of hand span and although the other examined indicators do not exhibit statistically important difference, they too follow the trend for generally smaller sizes. It is noteworthy that LW, RW and P have a greater % of BF compared to representatives of the other two positions. Despite the lack of credibility in intergroup comparisons, this fact can be interpreted as specific morphological trait that stands out against the background of their total smaller body sizes. Additional reason to focus attention on this fact are intergroup differences when BMI data are analyzed. There is a clear trend, albeit without statistical credibility, that LW, RW and P female handball players have a more pronounced body feed than that of LC, RC, CB players.

CONCLUSIONS

1. The outcome of the research demonstrates clearly that compared to other female athletes, handball players are relatively taller but their body weight is close to the average for women athletes. Further, they have a relatively greater amount of active body mass and absolute amount of muscle mass and develop specific larger upper leg muscles.
2. Where players occupying different game positions are concerned it has been found out that left wingers, right wingers and pivot players are generally smaller than representatives of the other two game positions but have a greater percentage of body fats thereof.

The results can be used in sports selection and morphological control of female handball players.

Reference:

1. Yotov, I, Gikova M. Power features and functional anatomy analysis of key throws in handball game. CH ., 1996 , № 5. 2.
2. Slunchev, P,Zaharieva, E, Toteva, M. Physical development of young female handball players. Jubilee Scientific Conference. Works of VIF – roll 11, 1976.
3. Slunchev, P. et al. Physical development , physical abilities and neuro-psychological reactivity of the population in Bulgaria 1980-1982 C ,NSA 1992
4. Slunchev P. Sports medicine. S., 1998.
5. Toteva, M. Somatotypology in sports. C ; NSA 1992 .
6. Taborsky F. Position-Related Categorization of somatotypes in Top Level Handball Players 2011, Vienna Austria. Publisher EHF Web Periodical 2011.

FURTHER TOPICS PRESENTED AT THE SCIENTIFIC CONFERENCE

THE EFFECT OF EXERCISE IN SAND COMPARED TO A FIRM GROUND MEASURED ON ANKLE STABILITY

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Background: Ankel injuries are considered the most common sports injury and in Denmark, ligament damage in the ankle counts for approximal 20% of all acute injuries. Several studies have shown that training of the muscles surrounding the ankle joint and training of proprioceptive senses, are key elements for ankle stability.

Purpose: The purpose of the present pilot study was to investigate whether training in sand has an effect on ankle stability, compared to training on firm ground.

Design and method: in the study where were included 26 healthy students from Holstebro Elitesport (14 boys and 12 girls) with ankle stability as the primary outcome, we used the Y balance test as a measurement tool at the start and at the end of the tests. By drawing lots, the participants were randomly distributed into two groups. Comparing one group exercising in sand, with the other group that were exercising on firm ground we tested whether training in sand was a more effective exercising method for obtaining a better ankle stability.

Result: based on findings from the Y balance test, exercising in sand were significant more effective on ankle stability than training on firm ground. P – values for both groups were below 0,05. Both groups improved, but the increase was significantly higher for the group exercising in sand. The average increase for the group were as follows: Exercising in sand: anterior direction from 5,22 to 6,44%, posterior medial 4,63 to 5,47%, and posterior lateral 4,15 to 5,23 %. Exercising on firm ground. Anterior direction from 0,83 to 1,04 %, postior medial 1,11 to 1,16 % and posterior lateral 0,81 to 1,19 %.

Conclusion: Based on present data, we can conclude that exercising in sand is more effective than exercising on firm ground in relation to ankle stability. Thus with high probability exercising in sand could be used as a supplement to improve the stability of the ankle joint.

**THE INVASION GAMES COMPETENCE MODEL:
AN ALTERNATIVE APPROACH TO TEACH HANDBALL AT SCHOOL**

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In the last decade, different approaches to the traditional technique-led to games instruction and learning have been proposed, such as The Invasion Game Competence Model (IGCM) (Musch et al., 2002; Graça et al., 2006). The IGCM uses modified game forms of the full game and confronts the players with real game issues (Graça & Mesquita, 2013). The purpose of this research was to examine student's learnings through the application of the IGCM to teach Handball at school. Therefore, the specific goals were to analyze student's improvements in decision making and skills execution and to explore the suitability of criteria-exercises proposed by Estriga and Moreira (2014). Fifteen twelfth grade students, from a Portuguese public secondary school, participated in a 13-lesson handball season, and were evaluated three times: in the first, seventh and last session. The sessions were all filmed for "offline" assessment of skills learning and game performance. A specific recording assessment tool was developed according to the level of handball practice. Data was analysed using SPSS 21 which was used to calculate the mean and the mean deviation for the three assessment moments and then to compared all three. Results showed that: (1) IGCM develops the game level of the students because the results were statistically different in game performance and skills execution between the first and the last moment of evaluation; (2) the adopted criteria-exercises revealed to be enhancers of the players' development and (3) the used performance indicators showed to be a useful tool although slightly impractical in real practice.

KNEE MUSCLE ACTIVITY DURING DYNAMIC AND STATIC EXERCISES ON UNSTABLE REHABILITATION EQUIPMENT

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Introduction: High activity of the hamstrings during handball sidecutting has been shown to be important to prevent anterior cruciate ligament injuries. Injury prevention programmes in handball are often performed on unstable rehabilitation surfaces like wobble-boards or balance-mats, but more information about the effect of each exercise may improve future program designs. The purpose of the present study was to examine the hamstring muscular activity elicited during landing and balance exercises on unstable compared to stable surfaces.

Material and Methods: Eighteen young subjects (11 men, 7 women), mean age 25.8 yrs, volunteered to participate. Subjects performed 3 dynamic landings from a horizontal jump on each of the following surfaces: a)floor, b)Airex mattress, or c)BOSU ball. EMG activity of the lateral and medial hamstring muscles during 100 ms pre and post landing was obtained as a measure of pre-programmed muscle activity and neuromuscular reaction to landing, respectively. Hamstring activity during standing balance was evaluated on: a)floor, b)Airex mattress, c)BOSU, and d)wobble-board. One way repeated measures ANOVA was used for investigation of differences between surfaces.

Results: Post-landing hamstring activity was significantly higher when landing on unstable surfaces compared to landing on the floor. During standing balance, the wobble-board showed significantly higher hamstring activity levels than the other surfaces. Hamstring activity was significantly higher during landing than during standing balance exercises.

Conclusion: Exercises on unstable surfaces increase the level of hamstring activity. Dynamic exercises seems to increase the hamstring activation level more, and it may be speculated that landing on unstable surfaces may be more efficient as injury prevention exercises.

THE INFLUENCE OF HIP JOINT CONTROL ON KNEE VALGUS MOMENT IN YOUNG FEMALE ELITE ATHLETES

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Background: In handball, young female players are more at risk of sustaining an Anterior Cruciate Ligament (ACL) injury during sidecutting. High knee valgus moments have been related to increased risk of ACL injury, but further knowledge is needed on how hip strength and hip joint control may influence valgus moments during sidecutting. The aim was to investigate the relation between isolated hip muscle strength, hip kinematics and knee valgus moments.

Materials and methods: 97 female handball and football players aged 15-19 yrs selected for the youth national teams were recruited. Maximal isometric hip strength was measured during hip abduction, hip extension and hip external rotation [N/kg BM]) by a handheld dynamometer. A standardized sidecutting was performed by each player and hip joint kinematics was measured at initial contact (IC) along with identification of the peak knee joint valgus moment in the contact phase. Regression analysis was used to determine which of the measured parameters would affect knee valgus moment, and as such represent potential risk factors that should be targeted in future prophylactic training regimes.

Results: No relation between maximal isometric hip muscle strength and knee valgus moment was found. Regression analysis showed weak but significant effect of hip internal rotation and hip abduction at IC on knee valgus moment (r^2= .33, $p<0.001$, β-coefficients = 0.49 and 0.35 for hip internal rotation and hip abduction, respectively).

Conclusions: The study showed that isometric hip muscle strength did not relate to peak knee valgus moment in young female elite handball and football players. However, increased hip internal rotation and increased hip abduction appeared to negatively influence the magnitude of knee valgus moment during sidecutting, and thus potentially increase the risk of ACL-injury.

PREVENTION IN MODERN HANDBALL

Dr. Ciocoiu Florin, Dr. Omer Senol – Emin

Testing the elite athletes is one of the principal activities of sports medicine. The first condition for the athletes to participate at testing programs for performance and physiological capacity is to be healthy.

Method: First a clinical general examination, an ECG and blood pressure measurement are necessary. After the athletes pass these medical examinations they can perform the specific stress testing – Aerobic Endurance Fitness Test and Anaerobic Capacity Fitness Test.
The results are read by the sports medicine physician.

These evaluations are important for cardiac prevention, for evaluating the athletes' performance and biological preparations based on scientific parameters useful for training and sports competitions.

"REHAB CAN WAIT" - SWEDISH HANDBALL PLAYERS CONTINUE PLAYING DESPITE INJURY AND PAIN

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Swedish handball lacks epidemiological data of injury frequencies. Hereby studies of preventive strategies impossible since there exists no baseline-data. This pilot-study aimed to evaluate injury frequencies and the self-assessed impact of an injury among Swedish handball players with special emphasis on those reporting shoulder- and knee injuries.

Material/Methods: A questionnaire was used to register self-reported-injuries. The questionnaire has been sports specifically developed for handball based on the OSTRC - **Overuse** Injury **Questionnaire** and tested for reliability. All players from age 15, in two independent handball clubs, were asked to participate during a training-camp.

Results: All attendants (n=186) choose to fulfil the questionnaire. Thirty-one players (17%) reported an acute injury during the last 7 days, all without insurance claims. Eighty-six (46%) reported an overload injury during the last 7 days. Forty-three players (23%) reported an overload problem in the shoulder. Thirty-seven continued practice handball as usual or with small dosage changes. Their reported pain-levels differentiated, but 26 reported moderate to severe shoulder pain. Thirty-six players (19%) reported an overload problem in the knee. Twenty-seven reported that they continued practice handball as usual or with small dosage changes. Their reported level of pain differentiated, but 12 reported moderate to severe knee pain.

Conclusion: This study presents that handball-players keep on playing despite injury and pain. In order to enhance recovery, the player needs to stop playing or change the level of activity required for rehabilitation and then return to sports. This problem needs to be addressed by players, coaches and medical teams.

SHOULDER INJURY IN HANDBALL PLAYERS: RELATIONSHIP WITH STRENGTH PROFILE

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The aim of this prospective study was to identify, among isokinetic results (intrinsic risk factors), the factors that could potentially put handball elite players at risk of shoulder dominant traumatic and micro-traumatic injuries.

One hundred and eight high level men handball players were enrolled into that study. Before the beginning of the season, the players completed a preseason questionnaire and performed a bilateral shoulder isokinetic assessment of the rotators (in supine position, arm at 90° abducted in the frontal plane, in concentric and eccentric mode of contraction). The players reported any shoulder pain or injury that they experienced during the season in a monthly questionnaire.

22% (23/106 players who completed the in season questionnaire up to the end of the season) of the players showed a shoulder lesion on their dominant side during the season, 14% (n = 15) suffered from micro-traumatic lesions during the off season and 7.5% (n = 8) described a traumatic injury. Backcourt players had 3.5 times more risk of pain during the new season (odds ratio= 3.24; p = 0.0112) than other player positions and players with a defensive exclusive role in the game were at 8 times less risk of pain during the subsequent season (odds ratio= 0.129; p = 0.0291). The odds ratio calculated showed that the maximal concentric strength developed by IR at high speed (240°.s-1) was a protective factor (odds ratio = 0.93; p=0.0487) for traumatic injuries. No risk factor for further injury was identifies in handball players with micro-traumatic lesions among the isokinetic results.

The results of the present study indicate that a preventive program with controlled concentric contraction including internal rotation at high speed (throwing ball, elastic band) should be advocated for individual handball players.

SHOULDER INJURY PREVENTION EXCERCISES IN OVERHEAD ATHLETES: A SYSTEMATIC REVIEW

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Overhead patterns implicate injuries in athletes and there is a high percentage of shoulder injuries in overhead athletes. Implementation of early intervention injury prevention programs is crucial due to the shoulder muscle imbalance and increased risk for the shoulder injury. The aim of the study was to verify what kind of shoulder injury prevention program is most effective in non-injured overhead athletes as primary prevention approach. The following electronic databases were systematically searched: MEDLINE, PubMed, PEDro, CINAHL, SPORTDiscus™, the Cochrane Central Register of Controlled Trials (CENTRAL). This systematic review was registered in PROSPERO data (PROSPERO 2013:CRD42013005769. Conflicting evidence has been found. In majority papers pre-training outcomes (such as strength, power, throwing velocity) were significantly lower compared to post-training scores, however usually there were no significant differences between tested groups. Limited evidence was found for increase isotonic and isokinetic strength with elastic resistance training and core stability exercises versus control group with traditional strength training. Closed kinetic chain exercises were more effective than open kinetic chain in increasing of throwing velocity. Supervised resistance training exercises results in higher improvement of bench strength values compared to unsupervised resistance training.

RETURN-TO-SPORTS GROUP LUXEMBOURG

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Injuries to the Anterior Cruciate Ligament (ACL) often cause athletes, especially in female handball, to be out of the game for a longer period of time.

To allow a safe return to sports, there is consensus that athletes need to perform adapted functional and sport-specific exercises. In other words, after a successful rehabilitation with mobility, strength, proprioceptive and coordination exercises, the athlete needs to train these skills in an increasingly sports-like environment. Especially in amateur sports, there appears to be a gap between conventional postoperative rehabilitation and return to team sports. In order to allow for a secure "re-athletisation", physiotherapists and doctors of the CHL-Sports Clinic initiated a return-to-sports group in Luxembourg.

The main goals of this group are getting back the athlete to the previous level of performance, to restore complete function of the injured limb and to minimize the risk of re-injury through education of injury prevention exercises performed in an athletic environment.

Specific inclusion criteria as well as training program, containing sport-specific movements, sprinting, cutting, jumping and neuro-muscular control exercises will be presented. In order to document the progression of the athletes during the 12-week course, specific agility tests are planned. This should help to identify the right timing for the athlete to participate in the complete handball team training and competition with a minimum risk of re-injury.

THROWING SPORT IMPROVES SHOULDER PROPRIOCEPTION

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BACKGROUND: Important part of shoulder function is sensory motor system, responsible for awareness, coordination and feedback necessary to maintain a proper form and stability. Repetitive and high velocity overhead throwing with poor control can affect the balance between stability and mobility in the shoulder, ultimately leading to injury.

OBJECTIVE: The evaluation of shoulder joint position sense (JPS) of both shoulders of male handball players and both shoulders of non-athletic healthy male individuals.

PARTICIPANTS: 90 professional male handball players, and 32 healthy male volunteers, had participated in the study as a control group. The protocol had included the measurement of dominant and non-dominant shoulder proprioception by active reproduction of the joint position and the comparison of results within, and between, both groups. Measurement included flexion, abduction, internal and external rotation. JPS had been measured with electronic goniometer.

RESULTS: JPS of the throwing athlete's shoulder had proven to be significantly better comparing to the dominant shoulder of the control group at highest ranges of abduction (2,9°±0,3 vs. 4,1°±0,4, p=0.001), flexion (2,7°±0,2 vs. 3,2 °±0,3 p=0,035), internal rotation (2,1°±0,1 vs. 2,6°±0,3, p=0.045) and external rotation (2,3°±0,2 vs. 3,1°±0,3, p=0.012). Joint position matching at highest ranges among athletes was superior in the throwing shoulder as compared to the opposite one: abduction (2,9°±0,3 vs. 3,7°±0,3, p=0,019), flexion (2,7°±0,2 vs. 3,2 °±0,2, p=0,037), internal rotation (2,1°±0,1 vs. 3,1°±0,3, p=0,009) and external rotation (2,3° ±0,2 vs. 3°±0,2, p=0,022). Such differences had not been found in the non-dominant shoulders of the control group, with the exception of lowest angle of internal rotation. Athlete's joint acuity had proven significantly better in higher ranges of flexion and abduction than in the lowest ones.

CONCLUSIONS: Throwing athletes have a superior joint position sense in the throwing shoulder comparing to the opposite one and dominant shoulder of the non-athlete population. Joint acuity is increased in a higher level of shoulder movement.

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SHOULDER ISOKINETIC MUSCLE PERFORMANCE IN MALE PROFESSIONAL HANDBALL PLAYERS

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BACKGROUND: Muscle strength and endurance of the shoulder rotators is important for overhead throwing performance and dynamic glenohumeral stability. Isokinetic assessment of shoulder internal and external rotators is commonly used by clinicians to assess muscle performance.

OBJECTIVE: The aim of the study was to evaluate the external (ER) and internal rotator (IR) muscles isokinetic peak torque, total work and strength ratios in handball players.

PARTICIPANTS: The pilot studies included 48 elite division handball players of average age 24.0 (± 4.5 years), height 187,1 (±5,9) and weight 91,0 (±11,6) and 25 persons of control group of average age 22 (±1 years), height 174,0 (±9,7) and weight 71,2 (±14,9).

INTERVENTIONS: Isokinetic tests were performed concentrically at 90, 180, 270 and 360 deg/s using Biodex System 3 PRO in standard sitting position.

RESULTS: The differences between the athletes and controls regarding the peak torque at 180 deg/s and total work at 270 deg/s of the ER and IR muscles for dominant and non-dominant shoulder were statistically significant. The control group presented higher ratios (D85,8±26,9; ND82,8±23,4) than handball players (D65,4±13,3; ND63,0±16,0) – differences were statistically significant. There were statistical differences between dominant and non-dominant shoulder in both group for total work of the ER muscles. There were no statistical differences between dominant and non-dominant shoulder in both group for peak torque of the ER and IR muscles.

CONCLUSIONS: Handball players present higher isokinetic parameters comparing to normal population. The study establishes additional normative data on ER and IR muscle torque and total work on high-level male handball players. The results are important for the application and interpretation of isokinetic data of handball players for both basic knowledge and practical reasons.

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THE OVERLOOKED FACTOR OF HANDBALL INJURIES: PLAYING POSITIONS

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The aims of this viewpoint are to 1) provide a rationale for the consideration of playing positions for the analysis of injury occurrences in handball and 2) establish specific injury prevention programs. While on-court physical and technical performances in elite handball are largely playing position- dependent (Karcher and Buchheit, 2014), data on injury occurrence in handball are limited and are generally not reported according to playing positions (Moller et al., 2012). In fact, it appears that back players are likely more exposed to shoulder injuries than their team mates, since they generally shoot more often. They also receive and give a lot more physical contacts than the majority of the other players (more than wings but less than pivots) and are therefore more prone to suffer from the consequence of collisions (e.g., contusions, concussions, fractures). Pivots generally receive and give the highest number of body contacts in the team. They are also likely more exposed to back injuries, probably because they have to win a preferential position within the opponent the defence, mainly using their upper body. Wings players perform clearly more sprints (longer and faster) than the other players and suffer therefore more of high-speed running-related injuries (i.e. hamstring strains). Goalkeeper have been shown to suffer more from elbow injuries, which is likely related to their specific upper-body actions when stopping balls with the distal extremities of their arms. They also perform a lot of explosive actions such as jumps or leg lifts, which can cause specific muscle injuries. To conclude, the present viewpoint suggests that the consideration of playing positions in male elite handball has a wide range of implications, from the assessment of injury occurrence to the design of efficient injury prevention programs.

LARGER GLENOHUMERAL ROTATION DEFICITS ASSOCIATED WITH SHOULDER PATHOLOGY AMONG PROFESSIONAL HANDBALL PLAYERS

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Glenohumeral internal rotation deficit (GRID) in a throwing shoulder might be major problem in athletes. The purpose of the study was to explore the shoulder rotational parameters and correlate them with the presence of shoulder pain and morphological changes among professional handball players.

Methods: 87 professional handball players participated in the study. Study protocol included: measurement of range of internal (IR) and external rotation (ER), identification of the shoulder pain and ultrasound (US) scan.

Results: There were significant associations and differences of rotational parameters in relation to pathological findings:

- shoulder pain associated with decreased ER and TAM. Pain affected 67% of players having GIRD >20^{o} (vs. 37% with lower deficits).
- Internal impingement coexisted with decreased rotations and larger TAMD diagnosed in 50% of cases having GRID >25% (vs. 13%) and 43% having TAMD >20% (vs. 13%).
- Partial RCT associated with higher gain in ER. Gains in ER and TAM coexisted with higher incidence of partial RCT (18% vs. 8% and 35% vs. 24% respectively).

Conclusion: Any larger rotational deficits should warrant medical team’s attention, since GIRD higher then 20-25^{o} or TAMD larger then 20^{o} coexisted with pathological finings of shoulder pain, partial rotator cuff tear or internal impingement as seen on ultrasound scan.

SHOULDER ROTATIONAL PROFILE AND OCCURRENCE OF ROTATION DEFICITS AMONG PROFESSIONAL HANDBALL PLAYERS AND NON-ATHLETE POPULATION

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Occurrence of glenohumeral internal rotation deficits (GIRD) among throwing athletes and non-athlete population has not been clearly estimated. Purpose of the study was to compare the shoulder rotational parameters among professional handball players and non-athlete population and test the occurrence of among the populations.

Methods: 87 professional handball players and 41 healthy volunteers as the control group participated in the study. Study protocol included: measurement of range of internal (IR) and external rotation (ER). Following calculations has been made: GIRD, external rotation gain (ERG), total arch of motion (TAM), TAM deficit (TAMD), TAM gain (TAMG).

Results: Handball players revealed significantly higher ranges of IR, ER and TAM comparing to control group. The throwing shoulder in handball group showed significant decrease in IR and increase in ER comparing to opposite shoulder (no such difference for the control group). There were no significant differences between rotation deficits values and incidence (GIRD, TAMD, ERG or TAMG) between the study groups. Larger deficits occurred in handball and control groups respectively: 13% and 2% for GIRD>20^{o} , and 7% and 2% for TAMD>20^{o}

Conclusions: Handball players revealed typical shoulder adaptation with increased ER and decreased IR; heaving also larger rotational ranges then non-athlete population. Occurrence of rotational deficits although higher in handball players was not significantly different from non-athlete group.

DECREASE OF ELBOW PAIN IN HANDBALL GOALKEEPERS AFTER COMPLETING A SUMMER TRAINING PROGRAM: A CASE SERIES STUDY

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Introduction: Approximately 75% of goalkeepers experience elbow pain, caused by repetitive hyperextension and valgus load on the elbow during the blocking of the ball. A specific training program during the summer period is expected to have a positive influence on the recovery of elbow pain in handball goalkeepers.

Method: In a prospective case series Dutch handball goalkeepers with elbow pain followed a supervised training program. The effect of the training program on pain (VAS, NRS), strength (Jamar dynamometer) and function in daily life (DASH-NL) was evaluated at baseline (t0), after six weeks (t1), and after completion of the training program (t2), with follow-up after one month (t3), three months (t4) and six months (t5).

Results: Nine goalkeepers participated in the summer training program. After completing the training program (t2) all goalkeepers returned to their previous competition level and all showed clinically relevant improvements on pain (VAS >70% decrease, NPRS >66% decrease) and function (DASH-NL >95% decrease). These improvements persisted during the follow-up period (t3-t5). None of the goalkeepers missed a training or match during the follow-up season 2013-2014 because of elbow pain. On group level, compared to baseline (t0), significant improvements on the VAS (p=0.001), NPRS (p=0.000), DASH-NL (p=0.000) and strength in the affected arm (p=0.009) were found after follow-up (t5).

Conclusion: A training program for handball goalie's elbow consisting of specific strength training and gradual increase of elbow load during the summer period seems to improve function, and lead to full return to sports on previous competition level without re-injury in the next season. Further research on a larger scale is however indicated to confirm the results of this case series.

SPORT INJURY AND OVERUSE SURVEILLANCE IN HANDBALL: REVIEW OF SYSTEMS AND NEW PROPOSAL

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Handball is associated with high risk of time loss injury. Considering different injury definition the overall incidence is around 8-9 injuries per 1000 training hours this is why effective prevention is so important. Before preventive actions can be suggested for sports injuries a solid surveillance system is required in order to study their etiology, risk factors and mechanisms. There are some sports injury surveillance systems available in literature, but variability in injury definitions and poor study designs made us try to design our own surveillance system. Most of the available systems mix definitions of injury: a traumatic and overuse. Both lead to injury time loss but incidence differs in gender and age groups. We would like to present straightforward register of Sports Injury and Overuse Monitoring System (SIOMS). Completing the data starts collection of basic data (The Player Passport) at the beginning of time of interest (season, competition, camp) and is continued when the injury occurs (two different protocols: acute and chronic). In order to be helpful not only for the team physicians but also for the couches and team managers our report form contains information about the diet and types of training which can influence time loss injuries. There are several injury surveillance programs regarding handball and other sports in the literature. SIOMS system takes into account prevention and could be great information about its effectiveness. We are aware that the reports from medical staff underestimate the incidents of injury also because of inconvenient way of reporting systems. Our system is both online and mobile application (tablet, smartphone) that is less time consuming and easy to handle for collecting, archiving and managing the data.

FULL ARTHROSCOPIC AUTOLOGOUS MATRIX-INDUCED CHONDROGENESIS FOR TALUS CARTILAGE DEFECT

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INTRODUCTION: One of the methods of cartilage ankle reconstruction is Autologous Matrix-Induced Chondrogenesis (AMIC). AMIC is a variant of the microfracture method. It makes use of a collagen membrane that serves as a scaffold for new cells and allows effective reconstruction of even large fragments of damaged cartilage surface. Currently, such procedures are performed by means of surgical opening of the ankle joint.

OBJECTIVES: The goal of the study is to present the surgical technique of arthroscopic treatment of chondral or osteochondral defects in the ankle using the AMIC technique and to present 2 years follow-up results.

METHODS: Our arthroscopic technique: the damaged cartilage and bone is removed using surgical spoon or shaver. The next step is to perform microfractures or to drill into the bone using a 1.1 mm K wire at intervals of 5 mm. In osteochondral defects a subchondral shape of the talus is created by use of bone substitute mixed with aspirated bone marrow from the tibia. Round collagen membrane patches are cut out by use of round scissors and in terms of dry arthroscopy are implanted into the cartilage defect area. Then the patches are stabilized by use of tissue glue. After five minutes, 10 movements of the ankle are performed ensuring the membrane remains in place. We have operated 20 patients with all arthroscopic AMIC technique.

RESULTS: After 24 month in AOFAS scale improvement from 44 points before to 82 after one year, Povacz from 15 points to 23 after one year, VAS from 4 points before to 9 after1 year.

CONCLUSION: We have presented a simple, entirely arthroscopic technique for reconstructing extensive cartilage defects with and without bone defects. Results of treatment are good and promising for future investigations.

MINIMAL INVASIVE ENDOSCOPIC TECHNIQUE FOR ACHILLES TENDON RECONSTRUCTION

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Achilles tendon ruptures are a common clinical problem. There are many techniques of Achilles tendon reconstruction; however, there is little evidence that either of them is clearly superior to others. The most common techniques have been founded on augmentation of the plantar tendon, peronus brevis tendon and flexor hallucis longus tendon.

We would like to present a novel procedure of Achilles tendon reconstruction using the hamstring grafts. This technique had been used by the author in so-called "difficult cases" as a "salvage procedure". We have been used this technique as a “open procedure” since 2011, but decided to upgrade it to minimally invasive, endoscopic procedure in 2015. This type of Achilles reconstruction limits the risk of damaging surrounding tissue. The use of the hamstring autograft is safe and reduces autoimmune reactions. We have been used this technique for 5 years, operated 18 patients with good or very good results.

MENISCAL WRAPPING REGENERATION TECHNIQUE IS THE EFFICIENT TOOL TO SAVE THE MENISCUS IN THE YOUNG ATHLETES

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Nowadays, traumatic meniscal injuries are constantly on the increase, especially in young athletes. Recognition of the great importance of the functional role of the meniscus has resulted in the adoption of an increasingly preserving approach. Even though recent decades have seen considerable developments in arthroscopic meniscectomy techniques, handball players undergoing this treatment often present, in the long run, clinical symptomatology severe enough to compromise their participation in competitive sport. Hence the treatment of meniscal injuries in athletes has become more and more preserving in recent years, through recourse to surgical techniques such as meniscal repair, biological replacement implantation and donor meniscus implantation, which allow pain relief, return to competitive activities and stable long-term results, slowing down arthritic progression. This paper described the results of a prospective analysis of the 2 year follow up of clinical and MRI results of 8 young athletes having been treated with a newly developed surgical technique of meniscus regeneration and ACL reconstruction. The surgery was performed by suturing and wrapping menisci in a collagen matrix, followed by the injection of a bone-marrow blood collected from the tibial proximal epiphysis, into the area of the meniscal lesion. The statistically significant improvement in IKDC 2000 clinical assessment and in IKDC 2000 subjective and Lysholm scores between preoperative (D, 45,93 and 65,43 respectively) and the 2-year follow-up time points (A, 90,33 and 95,43 respectively) were observed. Barret criteria demonstrated improved clinical outcomes between pre- and post-operative values. MRI revealed a non-homogeneous signal without meniscal tear in 76% of the operated menisci and homogenous in 13%. The data demonstrate that this technique can offer an additional tool to save the meniscus in the patients otherwise scheduled for meniscal removal.

FULLY ARTHROSCOPIC KNEE AUTOLOGOUS MATRIX-INDUCED CHONDROGENESIS 2 YEARS RESULTS

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We have developed a fully arthroscopic approach for the use of Autologous Matrix-Induced Chondrogenesis (AMIC) in the knee in 2010. The study is to evaluate change over time of clinical scores and morphological MRI of cartilage appearance after full arthroscopic AMIC of the knee. From a database of AMIC patients, all consecutive patients (age 13-63) treatment of knee cartilage lesions by AMIC from April 2010 to December 2011 were identified. All patients had been assessed preoperatively, and 6, 12 and 24 months postoperatively. Following information have been recorded: IKDC 2000 subjective score, IKDC 2000 clinical evaluation score and Lysholm score. All patients in the study had been assessed with MRI (morphological sequences) 6, 12 and 24 months postoperatively. Twenty-eight patients were identified for analysis with a median follow-up of 2 years (2,0–2,6). There were 23 patients treated with concomitant knee procedures such as ACL or PCL reconstruction, meniscal treatment and medial patelo-femoral ligament reconstruction. We had observed statistically significant improvement for Lysholm scale from 70,9 preoperatively to 86,5; 86,9 and 87,6 respectively 6, 12 and 24 months postoperatively, (p=0.001). We had also observed statistically significant improvement for IKDC subjective score assessment from 47,5 preoperatively to 69,8; 74,6 and 77,2 respectively 6, 12 and 24 months follow up with p=0.001. Tissue filling was present but often not complete or homogenous when evaluated with MRI. The cumulative modified MOCART (Magnetic Resonance Observation of Cartilage Repair Tissue) results had no correlations with both clinical or subjective scores results. Full-arthroscopic AMIC technique is safe and feasible for the treatment of symptomatic knee lesions and resulted in a progressive clinical improvement. Patients with concomitant knee procedures can also benefit from this treatment option.

ATTENTION CONCENTRATION AND SPEED AND DISTANCE ESTIMATION IN JUNIOR HANDBALL PLAYERS

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Attention, as a mental function, it ensures the triggering, maintaining and optimization of the cognitive processes. Physical movement involves both spatial perception and temporal perception. Estimating speed and distance falls under the skills category called "hard skills". The purpose of our research consists of investigating the concentration and mobility of attention (expressed through: attention efficiency coefficient and performance coefficient), as well as, the speed and the distance estimation and the scores obtained by the female junior handball players. The subjects who took part in this study were 14 female handball players, aged between 11-12 years old, having a competitive experience comprised between 1 and 2 years. The Attention Concentration and Mobility CMA Test and Speed and Distance Appreciation ADV Test, within PSISELTEVA tests, elaborated by RQ Plus, were used to evaluate the concentration of attention and the speed and distance estimation. Using the Spearman correlation there have been important relations highlighted between the results obtained by the junior female handball players at CMA and ADV tests and the sport performance (expressed through the number of goals scored in competitions, during the championship).

FUNCTIONAL RECOVERY AFTER ONE-SIDE ALL-ARTHROSCOPIC AUTOLOGOUS MATRIX INDUCED CHONDROGENESIS (AMIC) FEMORAL CONDYLE CARTILAGE REPAIR: A SOCCER CASES SERIES STUDY

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Introduction: It is still not common to use objective approach to analyse the therapy effectiveness in AMIC patients. Hence, it seems that conducting a study on the effectiveness of arthroscopic autologous and physiotherapy program is reasonable and justified. The aim of the study is an evaluate functional recovery in soccer-players after cartilage repair using the AMIC technique.

Materials and methods: The study was designed as a controlled laboratory study. 6 male soccer players from Polish Ekstraklasa (elite division) after one-side all-arthroscopic AMIC procedure. After 6 months of treatment isokinetic and proprioceptive evaluation was performed to access the functional recovery progress.

Results: The isokinetic and proprioceptive tests showed a significant improvement of muscle strength and endurance (knee extensors) from the beginning to the end of post-operative physiotherapy.There were no statistically significant differences between tested limbs regarding muscle endurance and tested proprioceptive parameters. Soccer players who underwent one-side all-arthroscopic AMIC had significantly lower results in isokinetic strength ($p=0.015152$) and endurance ($p=0.008658$) comparing to non-operated professional soccer.

Conclusions: 6 month of post-operative physiotherapy program for soccer players after one-side all-arthroscopic AMIC can provide the basis for a partly functional recovery and for restoring proper visuo-proprioceptive vestibulo-postural strategies of postural control. The multifactorial biomechanical assessment should be used to monitor the treatment process and to decide when it is as safe as possible to return to full sport activities.

EFFECT OF CHONDROPROTECTIVE TREATMENT ON KOOS SCALE PARAMETERS IN ATHLETES WITH POST-TRAUMATIC CHONDROPATHY OF KNEE JOINTS

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Traumas and post-traumatic disease lead to the decreased period of athletic career and decrease the quality of life of athletes. One of the directions of the drug therapy of knee joints diseases involves the use of the drugs from chondroprotectors group.

We formed 2 groups of athletes: handballers with post-traumatic chondropathy (main study group and comparison group). Athletes of both groups underwent the treatment course: physical therapy, kinetic therapy, massage. Athletes in the main study group were prescribed the treatment with chondroitin sulfate (Artradol). For subjective evaluation we used KOOS questionnaire (Knee injury and osteoarthritis outcome score). It was established that the use of chondroprotective therapy leads to decreased pain syndrome, increased sports activity and improved quality of life, which is confirmed by the significant difference in the parameters of KOOS sub-scales “Pain”, “Symptoms”, “Sports Activity”, and “Quality of Life” ($p<0.05$). Thus the use of chondroprotective therapy in treatment of athletes with post-traumatic chondropathy of knee joints is the more effective method based on the self-evaluation data.

USE OF CHONDROITIN SULFATE IN TREATMENT OF ATHLETES WITH POST-TRAUMATIC CHONDROPATHY OF KNEE JOINTS

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Post-traumatic chondropathy of knee joint involves pathological changes of hyaline cartilage characterized by disruption of its structures. The complications of the knee joints trauma include post-traumatic gonarthrosis, caused by the damage of the articular hyaline cartilage and weakness of the periarticular muscles.

The study involved 60 athletes-handballers. We formed 2 groups comparable in gender, age and degree of structural changes in the traumatized knee joints. Athletes of both groups underwent the treatment course: physical therapy, kinetic therapy, massage. Athletes in the main study group were prescribed the treatment with chondroitin sulfate (Artradol).

For the objective evaluation of functional condition of knee joints we applied the method of isokinetic dynamometry, bilateral study with angular velocities 60°/sec, 180°/sec, 300°/sec. As the result of testing we detected significant decrease in the extensors deficiency between damaged and intact extremities in the main test group with the angular velocities - 60°/sec and 180°/sec. In our opinion the effect of the performed therapy on the results of isokinetic testing is related to the symptom-modifying effects of chondroitin sulfate, manifesting as the decrease in pain syndrome.

COMPARISON OF RANGE OF MOTION TESTS WITH THROWING PERFORMANCE AND KINEMATICS IN ELITE TEAM-HANDBALL PLAYERS

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A lot of handball players experiences shoulder pain during their handball carrier. In baseball altered shoulder mobility (increased external rotation) is found to stress the glenohumeral structures of the shoulder and thereby the disposition to shoulder pain and shoulder injuries. However, in these studies passive range of motion (ROM) tests are conducted and not the actual range of motion during throwing. The question rises if the measured ROM of the shoulder also influences the real throwing kinematics in handball. Therefore, the aim of this study was to compare the active and passive ROM of the glenohumeral external rotation with the maximal external rotation and throwing performance during different throws with different wind-up techniques in elite team-handball players. Twenty-two elite handball players participated in the study in which the maximal ball release velocity and maximal external rotation angle during standing, with run up and jump throws with two types of wind-ups were measured together with the maximal active and passive glenohumeral ROM of the external rotation lying supine on a bench. Significantly higher maximal external rotation was found during the throws with the whip-like wind-up in comparison to circular-like wind-up throws together with a significantly lower external rotation during the active ROM test. No significant correlations were found between the ROM of the external rotation with the maximal ball release velocity and the maximal external rotation measured during the throws ($r \leq 0.29$; $p \geq 0.183$). It was concluded that ROM of the external rotation measured on the bench does not give any information about the maximal throwing performance or the external rotation angle during throwing and therefore cannot be used to identify potential fast throwers or injuries in elite team-handball players.

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