ARE TALLER HANDBALL GOALKEEPERS BETTER? CERTAIN CHARACTERISTICS AND ABILITIES OF SLOVENIAN MALE ATHLETES

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Abstract:

Although previous studies have found that body height and body mass are relevant for the selection of handball goalkeepers, there is still a dilemma whether taller goalkeepers actually have any advantage over the shorter goalkeepers in certain performance characteristics. Therefore the purpose of this study was to evaluate the chosen anthropometric characteristics and psycho-motor abilities of Slovenian handball goalkeepers with a particular emphasis on the group of taller goalkeepers. Goalkeepers were classified into two groups: a group of taller goalkeepers (TG>185 cm, n=24) and a group of shorter goalkeepers (SG≤185 cm, n=18). Different tests were used to assess hip flexibility, agility, explosive arm and leg strength and basic sensory functions. Differences in the selected variables between the groups were tested with independent samples *t*-test. Correlations between the variables were established using Pearson's correlation coefficient statistic. The level of significance was set at $p<.05$. The taller goalkeepers generated more energy ($p\leq.05$) in squat jump and countermovement jump performance than the shorter goalkeepers. The two groups of goalkeepers did not differ significantly either in body mass or in body mass index (BMI). The established correlations for the whole sample of goalkeepers revealed that body height had a negative influence only on the average simple reaction time. Likewise, body mass and BMI had a negative influence on the scores in the explosive leg strength tests. The results confirmed the opinion of handball experts that taller goalkeepers should be preferred in the process of selecting athletes for goalkeeping in handball. However, the values of body mass should specifically be considered, as well as certain motor and perceptual abilities.

Key words: *physical fitness, biomechanics, tall athletes, sensory functions, energy expenditure, body size*

Introduction

Correlation among different characteristics, skills, abilities and performance in sport has received much attention in recent years. The question 'what determines a top-level athlete' is an eternal dilemma both in kinesiology (sport and exercise science) and in sports practice. Team handball is a dynamic sport, in which different anthropometric characteristics, motor skills and abilities of players determine their playing positions. The goalkeeper is the most specific player among all his/her teammates (Srhoj, Marinovic, & Rogulj, 2002). He/she plays an important, some experts say a decisive, role in team performance (Dumitru, 2010) being the first and the last line of defence, and also the first and the last attacker.

As demonstrated in several previous studies, body height (BH) and body mass (BM) are important criteria for the selection of goalkeepers. Srhoj et al. (2002) described top-level goalkeepers as athletically built players with, preferably, pronounced longitudinal dimensions. They found that some international-level handball goalkeepers had the average BH of 191.86 cm and the average BM of 91.79 kg. Similar results were found by Urban, Kandráč, and Táborský (2011) who analysed young international-level goalkeepers. Some studies of the European handball players have demonstrated (Gorostiaga, Granados, Ibanez, & Izquierdo, 2005; Massuça & Fragoso, 2011) that more successful handball players and goalkeepers are mainly taller and/or heavier, that they have a higher percentage of lean body mass and a lower body fat percentage than the less successful players and goalkeepers. Although Hasan, Rahaman, Cable, and Reilly (2007) found no differences in BM and lean body mass between the successful and unsuccessful teams in the Asian Games handball tournament, on average, the successful teams were taller and had a lower level of body fat percentage than the players from less successful teams.

Other authors, however, did not find body height advantageous to goalkeeping performance. Visnapuu, Jürimäe, Jürimäe, and Allikivi (2011) also measured groups of taller and shorter goalkeepers and concluded that anthropometric characteristics were poor predictors of the performance of young top-level handball goalkeepers. Hasan et al. (2007) stated that BH and BM values of the Asian players were lower than the values of the European handball players studied previously. They also suggested the excellent play standard of the Egyptian and South Korean team was accomplished rather through their high technical and tactical performance than through body size of their players. Mohamed et al. (2009) have indicated running speed and agility, besides body height, to be important parameters for talent identification in team handball. It has also been found in several studies (Gardasević, Jakovljević, Pajić, & Preljević, 2011; Gorostiaga, et al., 2005; Hasan, et al., 2007) that handball-specific physique and a high level of strength and power may be beneficial to performance in handball.

Oxyzoglou, Hatzimanouil, Kanioglou, and Papadopoulou (2008) suggested high performance in team sports depends on well-developed and structured motor abilities of all players in the team, playing on their specific playing position. Therefore, goalkeepers should not be an exception. Chaouachi, Brughelli, Levin, Boudhina, Cronin, and Chamari (2009) even found performance indicators of jumps, sprints, squats, throws and aerobic capacity did not differ among playing positions. A study of Michalsik, Aagaard, and Madsen (2011) showed that goalkeepers had similar scores (e.g. in various vertical and horizontal jumping tests) as their teammates on other playing positions, or that goalkeepers scored even better (in countermovement jump test). Dumitru (2010) highlighted physical versatility of handball goalkeepers emphasizing the role of optimally developed motor abilities.

In some studies BH and BM were found to have a negative performance effect in the tasks of overcoming the resistance of one's own body mass. Erčulj, Blas, Čoh, and Bračič (2009) re-searched some antropometric characteristics and motor abilities of young elite female basketball players. It was found that centres, who were the tallest and the heaviest players in their teams, had the poorest scores in jumps, sprints and agility drills, meaning their BH and BM negatively affected the results in jumping tests. In sprints, the effect of BM and BH was slightly diminished. Erčulj, Bračič, and Jakovljević (2011), in their study with older subjects, confirmed the findings of Erčulj and associates (2009) to a certain extent. They found that BH and BM significantly influenced cyclic speed of high-performance female basketball players. Gardasević et al. (2011) demonstrated BH and BM had a negative influence on all power variables (standing long jump, standing triple jump, 20m run). In their research, elite junior basketball players, who were taller than the elite junior handball players, scored worse both in the standing long jump and in the standing triple jump test.

In handball, due to a great number of stimuli, perceptual skills play a cardinal role in performance (Zwierko, 2007). Mori, Ohtani, and Imanaka (2002) considered two types of perceptual abilities relevant to successful performance – first, sport-specific perceptual skills and, second, basic sensory functions (not specific to any particular type of sport expertise). Basic sensory functions have also been assessed by simple laboratory tasks using generic stimuli (e.g. simple reaction time task to a light flash). Kaur, Paul, and Sandhu (2006) suggested reaction time was a good indicator of performance in many ball games. However, there are no consistent findings in the studies using simple laboratory tasks as regards the differences between expert (experienced and/or highly qualified) subjects and non-expert subjects (novices and/or subjects with less expertise). Some studies, even in handball, have found statistically significant shorter simple reaction times in more experienced athletes than in novice athletes or non-athletes (Kaur, et al., 2006; Zwierko, 2007; Zwierko, Osiński, Lubiński, Czepita, & Florkiewicz, 2010), whereas some other studies found only small, not significant differences between athletes of different levels of expertise (Mori, et al., 2002; Paterson, 2010).

Taller and heavier people are believed to have longer reaction times, mostly due to inertia. Anson (1989) suggested the increased motor time was probably due to peripheral events, such as the duration of maximum torque which should be applied by the agonist muscle(s) to generate the required initiating rapid movement angular acceleration. Also, Chu (1989) established strong correlations between conduction (transit times) and slower responses by longer limbs, the lower and the upper alike.

Body height has been regarded an important anthropometric characteristic for the selection of handball goalkeepers for decades. However, an issue has not been elucidated yet whether taller goalkeepers have actual advantage over shorter goalkeepers in handball-relevant performance situations. Namely, some authors found a negative influence of BH on certain goalkeeping performance indicators (Anson, 1989; Chu, 1989; Erčulj, et al., 2009; Erčulj, et al., 2011; Gardasević, et al., 2011). To be certain that tall goalkeepers are the best choice, the selectors must make sure these athletes are better than the shorter goalkeepers in most, if not all, factors of goalkeeping performance. Therefore, the purpose of the study was to evaluate anthropometric characteristics, certain motor abilities and basic sensory functions of the Slovenian handball goalkeepers. Tall goalkeepers were in the focus of the experiment.

Materials and methods

Participants

The sample consisted of 42 healthy male handball goalkeepers, members of the Slovenian First and Second Handball League. The national-team goalkeepers were not included in the experiment. There were 24 taller (BH>185 cm) goalkeepers in the experimental group (BH: 189.2±2.3 cm; BM: 90.1±10.1 kg; age: 22.9±4.1 years; playing experience: 12±3.5 years), whereas the reference group included 18 shorter goalkeepers (BH≤185 cm) (BH: 181.1±3.9 cm; BM: 87±9.7 kg; age: 25±5.2 years; playing experience: 13.3±5.5 years). All subjects participated voluntarily in the experiment that was performed in accordance with the Declaration of Helsinki. Before the testing, they were informed about the purpose and the procedure of the study.

Variables

Anthropometric characteristics. Body height (in cm), body mass (in kg) and *m. triceps brachii* skinfold of the subdominant arm (in mm) were measured for each subject (Marfell-Jones, Olds, Stewart, & Carter, 2006). Body height was measured with a stadiometer to the nearest 0.5 cm and an electronic scale was used to measure BM to the nearest 0.5 kg. The *m. triceps brachii* skinfold of the subdominant arm was measured with a calliper to the nearest 0.5 mm. Body mass index (in kg/m²) was calculated as individual's BM divided by the square of body height (according to WHO). All measurements were performed by the same investigator.

Motor abilities. The following abilities were assessed for each subject: hip flexibility, explosive leg and arm strength (jumping strength/power and throwing strength/power) and agility. After ten minutes of a low and moderate intensity warm-up with dynamic flexibility exercises, the participants performed several submaximal short sprints, jumps, throws and agility drills for five minutes. Prior to every motor ability test, two trials were allowed for a specific warm-up. *Hip flexibility* was determined using the test *leg abduction test* (Pistotnik, 1991), in which a subject, lying on the hip, has to raise the extended right leg as high as possible and keep it there for three seconds. The feet have to be parallel with the floor and the back side of the body has to be skintight on the vertical plate throughout the testing. The angle (in °) between the initial and the final position of the thigh was measured with a goniometer to the nearest 1°. The goniometer was placed above the right knee. The subjects performed three trials, and the best result was used for further analysis. A variety of *vertical jumps with hands on the hips*, that is *squat jump, countermovement jump*, and *drop jump* (the height of the box was 45 cm) (Bosco, 1999) and *standing long jump* were used to assess *explosive leg strength (jumping strength/power)* (Bosco, 1999; Erčulj, et al., 2009). All measurements and calculations were performed with the OptoJump measurement technology (Microgate, Italy), which was connected to a computer. The height of the vertical jumps (in cm) was measured to the nearest 0.1 cm and energy invested in every jump (in J) was calculated to the nearest 0.1 J. In *standing long jump* the distance (in cm) was measured with a measuring tape to the nearest 1 cm. In *drop jump* the contact time (in seconds) after landing on the mat was measured to the nearest 0.01 second. The subjects performed three trials with 30 seconds of rest between the trials. The best result was used for further analysis. Three minutes of rest were allowed between different types of jumps. *Explosive arm strength (throwing strength/power)* (Erčulj, et al., 2009; Šibila, 1995) was assessed using the *medicine ball one-arm throw test* (Šibila, 1995), in which the subject used an overarm technique to throw the medicine ball (0.8 kg) as far as possible. The subject stood with his toes on the starting line (feet were parallel), and was not allowed to move his feet from the floor before releasing the medicine ball. The throwing distance (in m) was measured with a measuring tape to the nearest 0.1 m. The subjects performed three trials with 30 seconds of rest between the trials. The best result was used for further analysis. *Agility* was assessed using the *lateral steps* test (Šibila, 1995), in which the subject performed lateral shuffle steps to move as fast as possible between the two lines four metres apart. The subject stood in front of the first line with his hip turned in the movement direction (towards the second line). After the starting signal, he moved towards the second line where he stopped (he had to step on or beyond the second line with the leg closest to it), changed the movement direction and moved back to the first line where he stopped again (he had to step on or beyond the first line, now with the other leg) and changed the direction of moving again. The subjects had to move three times from the first to the second line and back to complete the drill. Time (in seconds) was measured with a stopwatch to the nearest 0.01 s. The stopwatch was stopped after the completed test, that is after the subject finally crossed the first line with the whole body. The subjects performed three trials with four minutes of rest between them. The best result was used for further analysis.

Basic sensory functions. *Basic sensory functions* were assessed by the results in the s*imple reaction time* test (Drenovac, 1994), in which a subject had to press a switch as quickly as possible when a signal (a single light flash) appeared on the machine plate. The test consists of 30 visual signals which are separated by various time intervals ranging from 0.01 to 3 seconds. The minimum and the average time were measured to the nearest 0.01 s. Before the measurement was taken, one warm-up trial was performed.

Statistical methods. The SPSS statistical package 20.0 was used for statistical analysis. Basic descriptive statistics of the variables were computed. The significance of differences between the groups was tested with *t*-test for independent samples and correlation between the variables was established using the Pearson's correlation coefficient statistic. The level of significance was set at p<.05.

Results

Basic descriptive statistics, differences between the groups and correlations between the variables are shown in Tables 1, 2 and 3.

No differences were found between the groups of goalkeepers in BM, BMI and *m. triceps brachii* skinfold of the subdominant, non-throwing arm (Table 1). Only two significant differences were found in the selected motor ability variables (Table 2) – the taller goalkeepers produced more energy (p≤.05) than the shorter goalkeepers in *squat jump* and *countermovement jump*. No differences between the two groups of goalkeepers were observed in the variables of the *simple reaction time* test (Table 2). For the whole sample (Table 3), BH, BM and BMI were positively correlated with the energy invested in *squat jump* and *countermovement jump* and with the throwing distance in *medicine ball one-arm throw* (the r values ranged from .328 to .692). Body height was also positively correlated with energy in *drop jump* (r=.317) and with average time in the *simple reaction time* test (r=.445). Body mass values and BMI were negatively correlated with the scores (height) in all vertical jumps (r values ranged from -.322 to -.532). Also, BMI and *m. triceps brachii* skinfold of the subdominant arm were negatively correlated with the distance in *standing long jump* (r values were -.399 and -.450).

Table 1. Results of the selected anthropometric characteristics

Variable (unit)	**TG**	**SG**	***t*-test (Sig.)**
Body height (BH; cm)	189.2±2.3	181.1±3.9	**0.000** *
Body mass (BM; kg)	90.1±10.1	87±9.7	**0.331**
Body mass index (kg/m²)	25.2±2.7	26.5±2.6	**0.114**
M. triceps brachii skinfold of subdominant arm (mm)	9.3±4.1	9.3±3.2	**0.986**

Legend: **TG** – a group of tall goalkeepers; **SG** – a group of short goalkeepers;
* differences between groups; level of statistical significance is set at p≤.05.

Table 2. Results of the motor ability tests and of the simple reaction time test

Test – ***Variable (unit)***	**TG**	**SG**	***t*-test (Sig.)**
Leg abduction – ***angle (°)***	67.6±9	63.9±12.6	**0.272**
Standing long jump – ***distance (cm)***	248.8±16.2	241.8±14.5	**0.162**
Squat jump – ***height (cm)***	34.5±2.6	33.2±3.9	**0.225**
Squat jump – ***energy (J)***	304±34.5	279±30.7	**0.022** *
Countermovement jump – ***height (cm)***	36.4±2.8	35.3±3.7	**0.264**
Countermovement jump – ***energy (J)***	320.1±37.6	297.4±30.5	**0.040** *
Drop jump – ***height (cm)***	33.8±4.7	32.9±6.5	**0.610**
Drop jump – ***contact time (s)***	0.21±0.03	0.23±0.04	**0.093**
Drop jump – ***energy (J)***	296.6±36.9	276.4±45.2	**0.123**
Medicine ball one-arm throw – ***throwing distance (m)***	24.8±3.4	22.8±2.6	**0.054**
Lateral steps – ***time (s)***	7.7±0.4	7.9±0.6	**0.321**
Simple reaction time test – ***minimal time*** **(s)**	0.16±0.01	0.16±0.02	**0.452**
Simple reaction time test – ***average time*** **(s)**	0.23±0.04	0.22±0.03	**0.174**

Legend: **TG** – a group of tall goalkeepers; **SG** – a group of short goalkeepers;
* differences between groups; level of statistical significance is set at p≤.05.

Table 3. Correlations between the variables

	Body mass index	***Body height***	***Body mass***	***M. triceps brachii skinfold***
Body mass index	1	-.158	.876**	.497**
Body height	-.158	1	.336*	.047
Body mass	.876**	.336*	1	.495**
Triceps brachii skinfold	.497**	.047	.495**	1
Leg abduction – *angle*	-.090	.111	-.019	-.266
Standing long jump – *distance*	-.399*	.252	-.249	-.450**
Squat jump – *height*	-.367*	.021	-.322*	-.252
Squat jump – *energy*	.490**	.375*	.666**	.242
Countermovement jump – *height*	-.409**	.090	-.332*	-.302
Countermovement jump – *energy*	.498**	.418**	.692**	.236
Drop jump – *height*	-.532**	.022	-.485**	-.270
Drop jump – *contact time*	.021	-.081	-.021	-.050
Drop jump – *energy*	.059	.317*	.225	.081
Medicine ball one-arm throw – *throwing distance*	.328*	.338*	.483**	.004
Lateral steps – *time*	.237	.039	.221	.092
Simple reaction time test – *minimal time*	.002	.220	.104	.026
Simple reaction time test – *average time*	.028	.445**	.251	.048

Legend: ** Correlation is significant at the .01 level (2-tailed); * Correlation is significant at the .05 level (2-tailed).

Discussion and conclusions

It is evident from Table 2 that the taller goalkeepers produced more energy than their shorter counterparts in the *squat jump* and *countermovement jump* tests. According to the basic laws of physics (Enoka, 1994), the amount of energy produced is calculated as:

$$\frac{1}{2} mv^2 \text{ (m = body mass; v = velocity).}$$

Higher values of the energy produced in jumps did not cause any difference in jumping height between the groups of goalkeepers due to the fact that the taller goalkeepers had slightly higher BM values. The established correlations between the variables (Table 3) showed that BM and BMI had a negative influence on the height of jumps. This influence was slightly stronger in the task which required rapid switching from eccentric to concentric contractions, that is, in drop jumps. The results in the jumping tests were lower than the results reported in some other studies on elite handball players (Gardasević, et al., 2011; Michalsik, et al., 2011). Therefore, it is feasible to say the level of leg explosive strength in our sample of goalkeepers was not high enough to compensate for the influence of their BM and BMI. As jumping performance is important to goalkeeping from the aspect of the required quick body displacement, the results of the jumping tests in our study suggest that more attention should be paid to the factors contributing to better jumping performance of goalkeepers (e.g. optimal ratio of BM and leg strength and power).

Since handball goalkeepers act individually within limited space, concentrated on quick and explosive implementation of simple movements in a fraction of a second (Srhoj, et al., 2002), not only the final result of an action (e.g. jump height or distance) is important, but also the acceleration of the entire body and limbs. Therefore, in *drop jump* tests we measured, besides the final height achieved, contact time as well. This parameter allowed for the comparison of the body deceleration-acceleration capability in both groups of goalkeepers. No significant differences were obtained in *drop jump* contact time between the groups of goalkeepers, although the taller goalkeepers achieved better results. This is an important piece of information since body height, due to inertia, could have a negative effect on acceleration of the whole body and its parts. Namely, according to the basic laws of physics (Enoka, 1994; Samaras, 2007), acceleration is inversely related to height and, therefore, it decreases with the increasing height ($a = F/m = h^2/h^3 = 1/h$; a = acceleration; F = force; m = mass; h = height).

This was not manifested in our study since the tall goalkeepers were capable to decelerate and accelerate at the same rate as the short goalkeepers. Other factors, most probably the differences in activation rate of leg muscles and/or the differences in the leg musculature and strength level, compensated for the previously mentioned potential disadvantage of body height. This assumption could be supported with the correlations for the whole sample of goalkeepers (Table 3), which revealed that BH was positively correlated with the amount of energy produced in *drop jumps*. A better explanation of these results would require accurate body composition determination and muscle activation rate testing. Also, for a better estimation of goalkeepers' capability to accelerate, they should be measured in match-specific and relevant conditions, i.e. not only in the tasks which require rapid eccentric-to-concentric contraction switching, but their take-off time should also be measured in other types of jumps (e.g. squat jump) and in other more goalkeeping-specific tasks (like lateral kick, single-leg lateral jump, etc.).

To assess agility, we measured performance in the *lateral steps* test (Table 2), which is quite specific for handball goalkeepers, as they perform many lateral movements (Dumitru, 2010). Speed of the movement direction change is potentially negatively related to the factors like body height, body fat percentage, and to the height of the athlete's centre of gravity (Sheppard & Young, 2006). In our study, however, the taller goalkeepers were capable to perform similarly as the short goalkeepers in the *lateral steps* test. Also, the correlations for the whole sample of goalkeepers (Table 3) revealed no effect of anthropometric characteristics on performance in agility test. The current finding is equal to the reported results of elite female basketball players, according to which BH and BM had no influence on the results in tests measuring agility (6x5 m drills) (Erčulj, et al., 2009; Erčulj, et al., 2011). The tests used in the mentioned studies were in some aspects comparable with the agility test in our study since they also included changes of movement direction and speed over short distances. Young, James, and Montgomery (2002) indicated that reactive strength of leg extensor muscles is to a certain extent important to change of movement direction performance; however, other technical and perceptual factors influencing agility performance should also be considered. First, it should be repeated here that the taller goalkeepers in our study scored similarly in jumping tests as the shorter goalkeepers. Further, the goalkeepers applied similar technique of movement in the agility test since they had approximately equal playing experience and, probably, similar environmental conditions for their development. If there was any deficit in stride rate among the tall goalkeepers, it could have been compensated for with the length of strides. For a better explanation of movement technique of goalkeepers, a biomechanical measurement should be implemented.

Explosive arm strength is, together with throwing technique, the most important factor that determines ball speed (Gorostiaga, et al., 2005). A high level of this motor ability is essential for goalkeepers as well, especially for the counter-attack execution, when a goalkeeper has to pass the ball to an open player very quickly and accurately (Dumitru, 2010). No differences in the results were obtained in *medicine ball one-arm throw* (Table 2) between the groups of goalkeepers although the taller goalkeepers scored better. Throwing tests' reults can be positively influenced by BH and/or BM (Erčulj, et al., 2009; Gorostiaga, et al., 2005: Srhoj, et al., 2002). The correlations for the whole sample of goalkeepers (Table 3) in the current study confirmed the reported findings since BH, BM and BMI had a positive influence on the results in the variable *medicine ball one-arm throw.* The shorter goalkeepers, most probably, compensated partially for the lack of BH with a stronger, more powerful upper body, which, however, was an additional load in jumping tests. The scores of drop jumps could support this explanation since the shorter goalkeepers were not able to decelerate and accelerate faster than the taller goalkeepers, as had been expected in line with the laws of physics. Accurate body composition determination and muscle activation rate testing are needed to better explain the obtained results.

Competition performance as well as injury prevention depends comprehensively on flexibility (Gruić, Ohnjec, & Vuleta, 2011). Oxyzoglou et al. (2008) indicated goalkeepers had better flexibility, mainly in the pelvis joint, than the players in other playing positions. In our study there were no differences in the *hip abduction* test between the taller and shorter goalkeepers as regards angles (Table 2). Higher flexibility levels facilitate reaching the ball thrown far away from a goalkeeper's position (Dumitru, 2010). Therefore, if both groups of goalkeepers achieved similar angles in *leg abduction*, the taller ones are in advantage since they have longer extremities which allow them to reach much farther from their position than the shorter goalkeepers. To get a more accurate conclusion in this respect, not only *leg abduction* but also other tests of flexibility should be implemented.

Some studies demonstrated that more experienced athletes had shorter simple reaction times than novice athletes or non-athletes (Kaur, et al., 2006; Zwierko, 2007; Zwierko, et al., 2010). Also, taller and heavier people can have longer reaction times (Anson, 1989; Chu, 1989). In our study we found no differences in the results of the *simple reaction time* test between the groups of goalkeepers (Table 2). The taller goalkeepers were able to react as fast as the shorter ones; however, the correlation in the whole sample of goalkeepers between body height and average simple reaction time was positive (Table 3). The finding can be explained with the taller goalkeepers' ability to compensate for the negative influence of body height by other factors. A better explanation of the results obtained requires accurate testing of factors that affect reaction time.

The results of the current study showed that the taller goalkeepers scored similarly as the shorter goalkeepers in almost all tests. This is in contrast with the studies by Erčulj et al. (2009), Erčulj et al. (2011) and Gardasević et al. (2011), in which scores of taller athletes were poorer in some tests. The different findings in their studies could probably be explained with either the extreme height of the investigated taller athletes (199 cm for young elite male players, 190 cm for elite female players, and 183 for young elite female players, on average) or/and with a large difference between the shortest and the tallest athletes (15 to 20 cm on average). The athletes in two studies were very young (age: 18.4 and 14.5) and there was, probably, a lack of lean body mass (muscle mass had not been developed to its full extent yet) in the tallest groups of the investigated athletes. The taller goalkeepers in our study were, on average, only 8 cm taller than the shorter goalkeepers. This difference is probably neglectable since BH did not affect negatively the performance in the selected motor tasks. From the aspect of the measured anthropometric characteristics and psycho-motor abilities, we could infer that the taller goalkeepers in our study might have an actual advantage in goalkeeping performance as they had a wider stretching range. Therefore, we suggest further investigation of the sample, with special emphasis on their body and limbs deceleration-acceleration capability.

Nikolaidis and Ingebrigtsen (2013) indicated that tall players, who had a higher percentage of fat-free mass, achieved better results in some (physical) performance indicators. The similar results were obtained by Srhoj et al. (2002), who suggested that higher values of longitudinal and transversal body dimensions as well as voluminosity of goalkeepers may considerably contribute to their ability to cover a broader part of the goal and to perform efficient save movements in peripheral parts of the goal. They also suggested the findings of their study were primarily caused by the selection and orientation of the players to particular positions in the game of handball. The selection of taller and athletically built goalkeepers however, could be an issue in some countries or geographical regions as there may not be as many tall players as needed, with athletic, mesomorphic body constitution who can perform quality enough. Therefore, shorter goalkeepers, whose motor abilities and performance are at a very high level, should be included in the selection process as well. The sport-specific kinesiological activities and training process may influence, to a certain extent, morphology of players, especially the measures of body voluminosity as well as lean–fat body mass ratio (Srhoj, et al., 2002). The selection should be a long-term process in which overall progress of goalkeepers must be monitored and managed. Our sugesstions regarding the importance of some suitability factors other than just anthropometric charateristics can be supported by a study with young high-level handball goalkeepers (Visnapuu, et al., 2011) in which the taller goalkeepers (193.5 cm and 88.2 kg) did not demonstrate better performance in actual matches than the shorter counterparts (185.1 cm and 80.9 kg).

We investigated handball goalkeepers with different body height values and managed to confirm, only indirectly, the opinion of handball experts that taller goalkeepers should be preferred in the process of selection. However, further studies should focus on the investigation of optimal body composition, or on optimal BH–BM ratio for goalkeeping performance. The current study has certain limitations. We did not include some goalkeepers of the highest quality level in Slovenia, e.g. national-team goalkeepers of Slovenia. Despite the fact that we tried to reveal the importance of certain psycho-motor abilities and anthropometric characteristics in our study, it is not quite clear yet how much effect they actually have on goalkeeping performance. We can suggest using more handball-specific motor ability tests with a special focus on speed and power tests.

Goalkeepers' performance in the present study, as well as goalkeeping performance in general, is probably more affected with other factors that were not investigated here, like, for example, skilled perception, or quality of team defence. The latter could represent a general problem, scientific and professional alike, since the quality of both hand-ball teams can mask the actual quality of goalkeepers, thus making the accurate assessment of goalkeeper's quality very difficult. Therefore, in addition to anthropometric measurements, a carefully designed testing of basic and specific perceptual and motor abilities of goalkeepers is suggested to be included in the selection process and repeated many times over the years. The testing should contain tasks that mimic actual goalkeeping movement patterns, being complex in their nature, or more goalkeeping-relevant indicator measurements, like, for example, the measurement of time goalkeepers of different body heights and other anthropometric characteristics and motor abilities need to get from one spot in the goal to the other, or relevant psychological characteristics determination, especially the sensorymotor ones. Obviously, a specific test battery for handball goalkeepers is needed if their performance is to be assessed as objectively as possible.

References

Anson, J.G. (1982). Memory Drum Theory: Alternative tests and explanations for the complexity effects on simple reaction time. *Journal of Motor Behaviour, 14,* 228–246.

Bosco, C. (1999). *Strength assessment with the Bosco's test*. Rome: Tipografia Mancini.

Chaouachi, A., Brughelli, M., Levin, G., Boudhina, N.B., Cronin, J., & Chamari, K. (2009). Anthropometric, physiological and performance characteristics of elite team handball players. *Journal of Sports Sciences, 27*(2), 151–157.

Chu, N.-S. (1989). Motor evoked potential with magnetic stimulation: Correlations with height. *Electroencephalography and Clinical Neurophysiology, 74,* 481–485.

Drenovac, M. (1994). *CRD – serija psihodijagnostičkih testova – priručnik.* [CRD – series of psychodiagnostics tests – a manual. In Croatian.]. Zagreb: AKD.

Dumitru, D.C. (2010). The importance of a specific warm-up on the performance of the handball goalkeeper. *Journal of Physical Education and Sport, 28*(3), 23–31.

Enoka, R.M. (1994). *Neuromechanical basis of kinesiology.* 2nd ed. Champaign: Human Kinetics.

Erčulj, F., Blas, M., Čoh, M., & Bračič, M. (2009). Differences in motor abilities of various types of European young elite female basketball players. *Kinesiology, 41*(2), 203–211.

Erčulj, F., Bračič, M., & Jakovljević, S. (2011). The level of speed and agility of different types of elite female basketball players. *Facta Universitatis Series Physical Education and Sport, 9,* 283–293.

Gardasević, B., Jakovljević, S., Pajić, Z., & Preljević, A. (2011). Some anthropometric and power characteristics of elite junior handball and basketball players. *APES, 39*(1), 5–9.

Gorostiaga, E.M., Granados, C., Ibanez, J., & Izquierdo, M. (2005). Differences in physical fitness and throwing velocity among elite and amateur male handball players. *International Journal of Sports Medicine, 3*, 225–232.

Gruić, I., Ohnjec, K., & Vuleta, D. (2011). Comparison and analyses of differences in flexibility among top-level male and female handball players of different ages. *Facta Universitatis Series Physical Education and Sport, 9*(1), 1–7.

Hasan, A.A.A., Rahaman, J.A., Cable, N.T., & Reilly, T. (2007). Anthropometric profile of elite male handball players in Asia. *Biology of Sport*, *24*, 3–12.

Kaur, P., Paul, M., & Sandhu, J.S. (2006). Auditory and visual reaction time in athletes, healthy controls, and patients of type 1 diabetes mellitus: A comparative study. *International Journal of Diabetes in Developing Countries, 26*(3), 112–115.

Marfell-Jones, M., Olds, T., Stewart, A.D., & Carter, J.E.L. (2006). *International standards for anthropometric assessment.* Potchefstroom: International Society for the Advancement of Kinanthropometry.

Massuça, L., & Fragoso, I. (2011). Study of Portuguese handball players of different playing status. A morphological and biosocial perspective. *Biology of Sport, 28*, 37–44.

Michalsik, L.B., Aagaard, P., & Madsen, K. (2011). Match performance and physiological capacity of male elite team handball players. In F. Taborsky (Ed.), *EHF Scientific Conference – Science and Analytical Expertise in Handball (Scientific and Practical Approaches)*, Vienna, 2011 (pp. 168–173). Vienna: European Handball Federation.

Mohamed, H., Vaeyens, R., Matthys, S., Multael, M., Lefevre, J., Lenoir, M., & Philppaerts, R. (2009). Anthropometric and performance measures for the development of a talent detection and identification model in youth handball. *Journal of Sports Sciences, 27*(3), 25–266.

Mori, S., Ohtani, Y., & Imanaka, K. (2002). Reaction times and anticipatory skills of karate athletes. *Human Movement Science, 21*(2), 213–230.

Nikolaidis, P.T., & Ingebrigtsen, J. (2013). Physical and physiological characteristics of elite male handball players from teams with a different ranking. *Journal of Human Kinetics, 38,* 115–124.

Oxyzoglou, N., Hatzimanouil, D., Kanioglou, A., & Papadopoulou, Z. (2008). Profile of elite handball athletes by playing position. *Physical Training* /on-line/. Retrieved June 8, 2012 from: http://ejmas.com/pt/2008pt/ptart_hatzimanouil_0806.html

Paterson, G. (2010). *Visual-motor response times in athletes and non-athletes*. (Unpublished Master's thesis, University of Stellenbosch). Stellenbosch: University of Stellenbosch.

Pistotnik, B. (1991). *Ovrednotenje različnih merskih postopkov gibljivosti.* [Assessment of different measuring procedures of flexibility. In Slovenian.] (Unpublished doctoral dissertation, University of Ljubljana). Ljubljana: Faculty of Sport.

Samaras, T.T. (2007). Advantages of shorter human height. In T. Samaras (Ed.), *Human body size and the laws of scaling, physiology, performance, growth, longevity and ecological ramifications* (pp. 47–50). New York: Nova Science Publishers.

Sheppard, J.M., & Young, W.B. (2006). Agility literature review: Classifications, training and testing. *Journal of Sport Sciences, 24*(9), 919–932.

Srhoj, V., Marinović, M., & Rogulj, N. (2002). Position specific morphological characteristics of top-level male handball players. *Collegium Antropologicum, 26*(1), 219–228.

Šibila, M. (1995). *Oblikovanje in ovrednotenje informacijskega sistema za iskanje nadarjenih rokometašev in za spremljanje njihovega razvoja*. [Design and assessment of an information system for identification of talented handball players and observation of their development. In Slovenian.] (Unpublished doctoral dissertation, University of Ljubljana). Ljubljana: Faculty of Sport.

Urban, F., Kandráč, R., & Táborský, F. (2011). Position-related changes in anthropometric profiles of top male handball players: 1980 and 2010. In F. Taborsky (Ed.), *EHF Scientific Conference – Science and Analytical Expertise in Handball (Scientific and Practical Approaches)*, Vienna, 2011 (pp. 208–213). Vienna: European Handball Federation.

Visnapuu, M., Jürimäe, T., Jürimäe, J., & Allikivi, P. (2011). Relationship between high level young handball goalkeepers' playing characteristics and body composition. In F. Taborsky (Ed.), *EHF Scientific Conference – Science and Analytical Expertise in Handball (Scientific and Practical Approaches)*, Vienna, 2011 (pp. 223–227). Vienna: European Handball Federation.

Young, W.B., James, R., & Montgomery, I. (2002). Is muscle power related to running speed with changes of direction? *Journal of Sports Medicine and Physical Fitness, 43,* 282–288.

Zwierko, T. (2007). Differences in peripheral perception between athletes and nonathletes. *Journal of Human Kinetics, 19*, 53–62.

Zwierko, T., Osiński, W., Lubiński, W., Czepita, D., & Florkiewicz, B. (2010). Speed of visual sensorimotor processes and conductivity of visual pathway in volleyball players. *Journal of Human Kinetics, 23*, 21–27.

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JESU LI VIŠI RUKOMETNI VRATARI BOLJI? NEKA OBILJEŽJA I SPOSOBNOSTI SLOVENSKIH SPORTAŠA

Premda su tjelesna visina i masa u dosadašnjim istraživanjima označene relevantnim faktorima za selekciju rukometnih vratara, još uvijek postoji dilema jesu li viši vratari uistinu u prednosti pred nižim vratarima kada se razmatraju određeni aspekti uspješnosti. Stoga je cilj ovoga rada bio evaluirati izabrane antropometrijske karakteristike i psiho-motoričke sposobnosti slovenskih rukometnih vratara, a osobita je pozornost poklonjena skupini viših vratara. Ispitanici su podijeljeni u dva poduzorka: viši vratari (TG>185 cm, n=24) i niži vratari (SG≤185cm, n=18). Različitim testovima procijenjena je fleksibilnost, agilnost, eksplozivna snaga ruku i nogu te osnovne osjetilne funkcije (percepcija i reakcija). Razlike u izabranim varijablama između dviju grupa testirane su t-testom za nezavisne uzorke, a Pearsonov koeficijent korelacije uporabljen je za otkrivanje korelacija između varijabli. Razina značajnosti za sve analize bila je $p<0.05$. Viši vratari su generirali više energije ($p\leq0.05$) od nižih vratara u izvedbi skoka iz čučnja i skoka s pripremom. Dvije se skupine vratara nisu značajno razlikovale ni po vrijednostima tjelesne mase ni indeksa tjelesna mase (BMI). Korelacije uspostavljene između varijabli za čitav uzorak rukometnih vratara pokazale su negativan utjecaj tjelesne visine samo na prosječno vrijeme jednostavne reakcije. Isto se tako pokazao negativan utjecaj tjelesne mase i BMI na rezultate u testovima eksplozivne jakosti nogu (skočnost). Dobiveni su rezultati potvrdili mišljenje rukometnih stručnjaka prema kojemu u procesu selekcije sportaša za poziciju rukometnog vratara valja preferirati tjelesno više rukometaše. Pritom, međutim, pozornost treba obratiti osobito na vrijednosti tjelesne mase, ali i na neke motoričke i psihičke sposobnosti.

Ključne riječi: tjelesna pripremljenost, biomehanika, visoki sportaši, percepcija, brzina reakcije, energetska potrošnja, veličina tijela