

Original Article

Analysis of the fitness level in elite handball players (U16 and U18) between 2003 and 2013

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Abstract:

This study uses standardised fitness tests to analyse the fitness level of handball players from a centre for talented players over ten years of age. The goal of this study was to analyse the fitness level of top junior handball players over ten years of age (from 2003 to 2013). A total of 177 participants were included in testing, including 11 younger adolescents (16–17 years old) and 166 older adolescents (18–19 years old). The players were tested twice each year (summer and winter) in six fitness tests (running 2 x 15m, dribbling 30m, five jump, medicine ball (1kg) throw, running 10 x 20m and 12 minute The Cooper 12 minute run test). The one-way ANOVA analysis and effect size were used for two repeated assessments. In the younger category, significant differences between the summer and winter testing of players were found in five tests (running 2x15m ($p = .00$), dribbling 30m ($p = .00$), five jump ($p = .00$), medicine ball (1kg) throw ($p = .014$) and running 10 x 20m ($p = .00$). In the second category, this was the case only for five jump ($p = .01$). The only test in which both categories deteriorated was the The Cooper 12 minute run test. The difference was not significant in any of the categories ($p = .16$ and $p = .21$ respectively). A comparison of the fitness level of players who have attended the centre and play top competition with the representative team in the country and abroad with those of the players who play lower (2. and 3. league) competition in the Czech Republic and attended the centre showed significantly difference ($p = .01$).

Keywords: conditioning, sports performance, talented players

Introduction

Handball is an Olympic sport that is played throughout the world on both amateur and professional levels by men, women, boys and girls. According to Póvoas et al. (2012) and Šibila et al. (2004), team handball is a complex and highly demanding intermittent sport, which requires that players have well-developed aerobic and anaerobic capacities. During a handball game, the players perform many accelerations, sprints, turns and jumps, and there is direct contact with opponents. There is substantial sprinting and maximum jumping in defence and offence; also, flexibility, throwing velocity, agility and coordinative abilities are indispensable for efficiently managing game situations (Boraczyński and Urniaz, 2008; Galal El-Din et al., 2011). Furthermore, a high level of aerobic capacity ensures the slower onset of fatigue and faster recovery, whereas anaerobic capacity is responsible for endurance in high intensity, repetitive activities (Galal El-Din and Ibrahim, 2011; Marques and Gonzalez-Badillo, 2006).

The available research on handball players indicates that physiological characteristics such as speed, strength and jumping abilities depend on the level of competition (Gorostiaga et al., 2006; Lidor et al., 2005; Marques and Gonzalez-Badillo, 2006; Xaverova et al., 2015). To improve their handball performance, elite level players must arrange specific handball conditioning work with some additional resistance, as well as sprint and endurance training (Jensen, Jacobsen, Hetland and Tveit, 1997). The results of the physical condition tests could allow coaches to diagnose and identify players' abilities, as well as possibly help in designing training programmes for improving specific skills according to playing positions and recording the players' improvement during a competitive season (Galal El-Din, Zapartidis and Ibrahim, 2011).

This article aims to evaluate various aspects of motor testing in handball. The first is that most previous studies have been conducted on non-elite players, and further investigation into the characteristics of elite players is needed. Such data would help handball players to evaluate their physical characteristics and physiological abilities, as well as help design specific training programmes (Ingebrigtsen and Jeffreys, 2012). The second fact arises from previous research indicating that certain physical characteristics are related to high-level handball performance (Gorostiaga et al., 2006; Lidor et al., 2005). The goal of this study is to analyse the fitness level of top junior handball players over a period of ten years (from 2003 to 2013).

Methods

Participants

The tested players were part of the Youth Sports Centre (SCM) in the town of Zubří, which focuses on handball. The system of sports centres is defined by government documents such as Act č.115/2001 Sb, with further adaptations and appendices amended by the Czech Government no. 718 of 14 July 1999 within the principles of comprehensive protection of the national teams, including the system of education of sports talents. The basic purpose of the activities of clubs with SCM status is to develop for talented individuals. Four SCM centres in the Czech Republic focus on handball and talented handball players who are prepared to meet the needs involved in representing the Czech Republic. This was a project of the Czech Handball Federation planned in 2002/3 and carried out properly during that period of time. Talented players from the SCM were compulsorily tested twice yearly by trained coaches over the course of ten years. Tested players were from the SCM sports centre in Zubří in the years 2003 to 2013. Players belonging to two age categories, 16–17 and 18–19, were included. A total of 177 participants participated in the testing. The players in 16–17 and 18–19 categories had average heights of $181.7 \pm 6.8\text{cm}$ and $183.5 \pm 5.7\text{cm}$ and weights of $72.6 \pm 9.0\text{kg}$ and $77.3 \pm 8.3\text{kg}$, respectively. Players had five training sessions (one session was 90 minutes) during the week. They played one competitive match every weekend.

Procedure

Testing of the SCM players' fitness levels takes place every year during the week before the first competitive match in August and one week before the first competitive match in February. There is a five-month period between the two testing events. Players are ranked in the SCM system only with the consent of their parents, who know about and always agree to the fitness tests. The weight and height of each player is always measured before the first test. The main supervisor of the tests is the chief coach of the Czech Handball Association (CHA), who remained in post throughout the ten years.

Standardised conditions were created to ensure maximum objectivity in the testing and subsequent evaluation of individual performances. The entire motor performance testing of the handball players lasted two hours. The players were verbally informed about each test before performing the first test battery. To achieve better performance, the verbal interpretation was supported by a practical demonstration, which prevented substantial deficiencies in the results arising from misunderstanding. All teams completed six tests in the order specified by the Commission of the Talented handball players (running 2 x 15m, dribbling 30m, five jump, medicine ball throw (1kg), running 10 x 20m and Cooper 12 minute run test). There was a one hour pause between the 10 x 20m test and the Cooper 12 minute run test. Players had fifteen minutes to warm up before testing. Players underwent testing in a fixed order. The player's best performance in each test was converted into points according to standardised figures. Testing was always performed in the same sports hall (artificial surface) on a handball court (20 x 40 m). The temperature in the hall was never below 20°C. Running events were measured by Alge Comet 1462 photocells (Austria). The CHA nominated one of the referees (always the same) and the Zubří club ensured one referee (always the same), two assistant referees and scorekeepers for each test. The testing conditions—such as the court, handball, sheets for testing different teams and additional record sheets for recording laps in the Cooper's test—were also consistent.

Conditioning tests

Additional information regarding the reliability, validity, objectivity and specific directions of these tests can be found in texts on the measurement and evaluation in sport and physical education. This test battery has been used in the Czech Republic since 1989. The last update of the normative tests occurred in 2005. The fitness level demonstrated by the performance of the SCM players has an impact on the allotted financial subsidy. Such criteria require responsibility and accuracy during testing. The test battery consists of six tests (running 2 x 15m, dribbling for 30m, five jump, medicine ball throw (1kg), running 10 x 20 m and the Cooper 12 minute run test). The motor tests and physical measurements are briefly described below. This battery of tests was selected to provide coaches with useful information on the motor, physical and skill level of the young handball players in the preliminary phases of talent detection and development. All tests were measured by photocell.

Agility test: Running 2 x 15m

Two parallel lines mark a 15m distance (Figure 1.). At the electrical timekeeping device, there is a parallel line 0.5m before the starting line to provide space for the starting position of the player. The electric clock stands at the level of the starting line. The player starts from the standing position and continuously runs two 15 metre sections in sports shoes. The player takes his position behind the additional line. The timer starts after the runner crosses the starting line. The player is allowed to change directions after he touches or exceeds the marked line with one foot. The test is completed by running two 15 metre sections. This test is performed twice using a flow method. The timer activates at the moment the runner crosses the line and measures the time taken to reach the second line with an exactness of 0.01 seconds. The criterion for evaluating performance is achievement of a better time. Both runs count in the assessment.

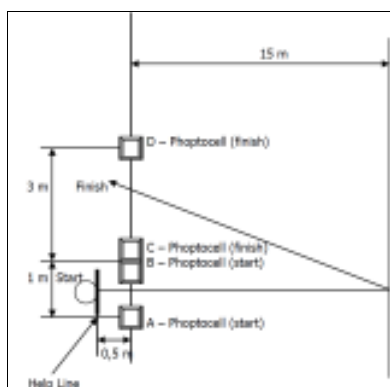


Fig.1. Agility test: Running 2 x 15m

Specific skill handball speed test: Dribbling 30m

This test is performed on a handball court with six handballs of weight and dimensions corresponding to the test category for male and female players, using a stopwatch or electric timer (photocells), measuring tape and adhesive tape. Two parallel lines mark the 30m section. At the electrical timekeeping device, there is a parallel line 0.5m before the starting line to provide space for the starting position of the player (Figure 2). Inside the 30m section, there is a line indicating the area where the ball hits the floor. The electric clock stands at the level of the starting line. The player takes his ready position directly behind the additional line and starts individually after the consent of the referee. This test is performed twice using a flow method. The player must not violate the rule of playing with the ball. The timer activates at the moment the runner crosses the line and measures the time taken to reach the second line with an exactness of 0.01 seconds. The criterion for evaluating performance is achievement of a better time. Both runs count in the assessment.

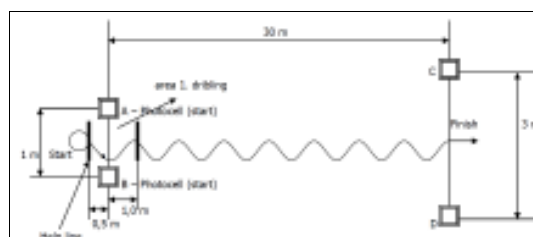


Fig. 2. *Specific skill handball speed test: Dribbling 30m*

Explosive Strengthpower test: Five jump

The measuring tape is placed on the ground with figures upwards. A zero value is placed at the outer side of the start line, which indicates the position of the first take-off. The player stands with his take-off leg behind the start line, which specifies the first take-off spot. The player executes five jumps along the measuring tape; the last jump can be with the legs together. This test is performed three times using the flow method and has an exactness of five centimetres. To assess the performance, a stick is used, which marks the final place of landing. The point of landing is the part of the foot or other body part closest to the starting point. Performance is rounded down to the nearest half centimetre (e.g. 10.54cm is written as 10.50cm). If any attempt violates the rules, the attempt is included but not measured.

Explosive strengthtest: Medicine ball (1kg) throw

The explosive strength test consists of a medicine ball (1kg) throw. At the goal line, there is a marked one metre wide section. The measuring tape is placed on the floor with figures upwards and perpendicular to the goal line. At a distance of 20m, two clubs mark the width of the sector—i.e. three metres on either side of the band (Figure 3). If there is a shorter tape, the zero sector is considered to be within 20m of the goal line with relating values added. The numbers should be marked close to the perpendicular line zone for faster and easier reading (e.g. one metre). The medicine ball must be verified prior to testing. Throws are executed from behind the goal line with the one-hand throwing technique. While performing the throw, the player must always have at least a part of one foot in contact with the ground (as for the seven metre throw). Line crossing is permissible only after throwing. The player performs three attempts in succession. The player must not cross the goal line while throwing and the ball must fall within the sector. All three attempts are recorded with an accuracy of ten centimetres. The distance is measured with an imaginary perpendicular line leading from the impact point of the ball to the goal line. If any attempt violates a rule, the attempt is included but not measured. The performance criterion of the test is the best performance.

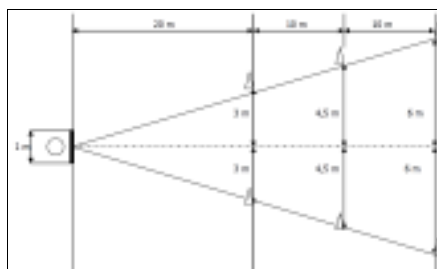


Fig. 3. Explosive strength test: Medicine ball (1kg) throw

Anaerobic endurance: Run 10 x 20m

The 20m section is marked by the centre and goal line. The test begins and ends at the centre line of the court. At the electrical timekeeping device, there is a parallel line 0.5m before the starting line to provide space for the player's starting position. The electric clock stands at the level of the starting line. The player takes his ready position behind the additional line. The player starts running at the signal of a measuring device. After the start, the player follows the route shown in Figure 4 according to the rules of the time-measured test. The players have to cross the finish line between photocells C and D. The test consists of running the route ten times. If the player violates the rules of the test or if there are other objective reasons (failure of the timer, etc.), the test is not complete and the referee may authorise a new attempt. The timer activates at the moment the runner crosses the line and measures the time taken to reach the finish line with an exactness of 0.01 seconds. The result is taken from one attempt and is considered the criterion of performance. If any rule is violated, the performance is not considered valid.

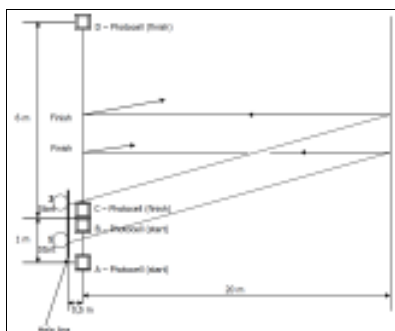


Fig. 4. Anaerobic endurance: Run 10 x 20m

Aerobic endurance: the Cooper 12 minute run test

A circuit (100m) on the handball court is marked with four clubs on each corner of the rectangle. The player starts from a standing position in sports footwear and a jersey with a number. Running can be alternated with walking. At 11 minutes and at 11 minutes 30 seconds after the beginning of the test, the players receives verbal information about the time. This information allows the runner to adjust the running pace. In the twelfth minute, an audible signal (a whistle or horn) indicates the end of the test. At this signal, the players have to stop running and stand still in their places. The number of metres run is measured with an accuracy of ten metres. For each player, the number of laps is recorded (on a printed sheet of records); the number of laps completed and the number of metres in an unfinished round are combined to yield a player's final distance. Finally, the total number of metres with the assigned accuracy is recorded on the sheet for all the tests. The local ethical committee and the committee on current ethical standards in sports and exercise research at Palacky University approved the research.

Statistical analyses

The statistical software package SPSS 17.0 (SPSS Inc., Chicago, IL) was used to calculate all statistical characteristics. Descriptive data were reported as the mean $\pm$ standard deviation (SD). To detect the differences between the two repeated measurements during every monitored season and to evaluate the relationship between the results and competition level, one-way ANOVA was used on the two repeated assessments and the coefficient of variation. The coefficient of variation (CV) was calculated as a typical error of measurement (TEM) expressed as a percentage of a subject's mean score. To calculate the TEM, the following formula was used (Hopkins et al., 2001): $TEM = S_{diff} / \sqrt{2}$, where S_{diff} is the standard deviation of the difference score between two measurements.

The effect size was calculated according to Xitao (2011) as $\omega^2 = \frac{[F \cdot (k - 1)] - k + 1}{[F \cdot (k - 1)] + n - k + 1}$, where F is the F-value from ANOVA, k is the number of groups and n is the number of participants. The statistical significances of the analysis were determined at an alpha level of $p < 0.05$.

Results

The descriptive results of the motor testing of the U16 category during the ten years have shown improvement in the players' performance during the season for running 2 x 15m, dribbling 30m, five jump, medicine ball throw (1kg), running 10 x 20m and total score, and a decrease in the Cooper 12 minute run test performance. Table 1 shows the results from the first and second assessments within the ten year observation period. The one-way ANOVA analysis and effect size were used on two repeated assessments of the U16 category. This group showed statistically significant differences with a high effect between the two measures during every season in running 10 x 20m ($F = 15.93$; $p = .00$; $\omega^2 = 0.15$), medicine ball throw ($F = 6.16$; $p = .01$; $\omega^2 = 0.10$), running 2 x 15m ($F = 16.13$; $p = .00$; $\omega^2 = 0.14$), dribbling 30m ($F = 15.35$; $p = .00$; $\omega^2 = 0.14$) and five jump ($F = 13.02$; $p = .00$; $\omega^2 = 0.13$). Non-significant statistical and practical differences between the results of the two measurements during every monitored year were found in the total score ($F = 2.07$; $p = .15$; $\omega^2 = 0.01$) and the Cooper 12 minute run test ($F = 1.96$; $p = .16$; $\omega^2 = 0.01$) (Table 2). Table 3 demonstrates the results from the summer and winter testing of the players' fitness levels.

Table 1. Comparison of summer and winter testing players (U16 and U18)

Tests of players (U16)	Summer fitness test	Standard deviation (SD)	Winter fitness test	Standard deviation (SD)
Run 2 x 15m (s)	5.55	0.16	5.47	0.16
Dribbling run 3 m (s)	4.50	0.17	4.42	0.15
Five jump (m)	28.23	3.65	29.51	3.78
Medicine ball (1kg) throw (m)	12.95	0.75	13.29	0.76
Run 10 x 20m (s)	41.27	1.12	40.72	1.33
Cooper run (m)	2814.58	203.52	2765.99	253.05
Points	34.04	7.99	38.40	7.73
Tests of players U18	Summer fitness test	Standard deviation (SD)	Winter fitness test	Standard deviation (SD)
Run 2 x 15m (s)	5.45	0.17	5.39	0.19
Dribbling run 30m (s)	4.38	0.14	4.36	0.17
Five jump (m)	13.57	0.77	13.92	0.86
Medicine ball (1kg) throw (m)	31.89	3.69	31.92	3.53
Run 10 x 20m (s)	40.03	3.46	40.02	1.44
Cooper run (m)	2894.95	210.63	2851.88	220.17
Points	34.81	8.42	36.85	10.11

Table 2. The correlation coefficient between summer and winter testing players (U16 and U18)

Players	Run 2 x 15m (s)	Dribbling 30m (s)	Five jump (cm)	Medicine ball (1kg) throw (m)	Run 10 x 20m (s)	Cooper run (m)	Points
U16	p .00*	.00*	.00*	.014*	.00*	.16	.15
U18	p .07	.42	.01*	.96	.97	.216	.16

Note. * $p < .05$

Table 3. Results from the summer and winter fitness tests of the players (U16 and U18) within ten years

Tests of players (U16)	Mean	Minimum	Maximum	Standard deviation (SD)
Run 2 x 15m (s)	5.51	5.15	5.90	0.16
Dribbling run 30m (s)	4.47	4.11	4.90	0.17
Five jump (m)	13.12	11.30	15.00	0.77
Medicine ball (1kg) throw (m)	28.83	20.30	40.20	3.78
Run 10 x 20m (s)	40.99	38.00	43.90	1.23
Cooper run (m)	2799.26	1830.00	3300.00	225.63
Points	36.28	18.00	54.00	7.97
Tests of players (U18)	Mean	Minimum	Maximum	Standard deviation (SD)
Run 2 x 15m (s)	5.43	4.97	5.88	0.18
Dribbling run 30m (s)	4.37	3.94	4.76	0.15
Five jump (m)	13.72	11.70	15.80	0.83
Medicine ball (1kg) throw (m)	31.91	23.40	41.00	3.61
Run 10 x 20m (s)	40.03	10.00	44.72	2.75
Cooper run (m)	2875.92	2050.00	3320.00	215.30
Points	35.69	11.00	55.00	9.22

The descriptive results of the motor testing of players in the U18 category during the ten years are shown in Table 1. The performance of players during the season increased in running 2 x 15m, dribbling 30m, five jump, medicine ball throw (1kg), running 10 x 20m and total score, and decreased in the Cooper 12 minute run test. Table 1 shows the results from the first and second assessments within the ten year observation period. The one-way ANOVA analysis and effect size were used on two repeated assessments of the U18 category. This category showed statistically significant differences with a high effect between the two measures during every season in the five jump ($F = 13.92$; $p = .01$; $\omega^2 = 0.10$). No significant statistical or qualitative differences between the results of the two measurements during a monitored year were found in running 2 x 15m ($F = 3.35$; $p = .07$; $\omega^2 = 0.02$), dribbling 30m ($F = 0.65$; $p = .42$; $\omega^2 = 0.00$), medicine ball throw ($F = 0.00$; $p = .96$; $\omega^2 = 0.01$), running 10 x 20m ($F = 0.00$; $p = .97$; $\omega^2 = 0.01$), the Cooper 12 minute run test ($F = 1.61$; $p = .21$; $\omega^2 = 0.01$) or total score ($F = 2.01$; $p = .15$; $\omega^2 = 0.01$) (Table 2). Table 3 summarises the results from the summer and winter fitness tests of the players within the ten year period.

Next, we compared the level of the league players after finishing the junior category and their total scores in the tests during their junior career. The level of the league players after finishing the junior category was higher for players with better scores on the tests for both the U18 ($F = 9.58$; $p = .01$; $\omega^2 = 0.03$) and U16 ($F = 7.33$; $p = .01$; $\omega^2 = 0.05$) categories.

Discussion

The goal of this study was to analyse the fitness level of top junior handball players during a period of ten years (from 2003 to 2013). The data in the present study could be added to the international literature and assist in the identification and development of talent.

Comparisons of the same motor tests with either Czech studies or studies performed abroad are considered irrelevant because, according to the available resources, identical fitness tests and analyses performed have yet to be recorded. Only Tuma (2007) provides a comparison of the score values in the summer and winter preparation periods for the SCM boys' teams in the Czech Republic, which resulted in the same conclusions as our study, with the winter fitness tests indicating a better condition in players than the summer testing. Although studies from other countries have reported the testing of young handball players (Chelly et al., 2011; Galal El-Din et al., 2011; Lidor et al., 2005; Mohamed et al. 2009; Nikolaidis & Ingebrigtsen, 2013; Zapartidis et al., 2009), we cannot base our procedure of testing on them due to the differences in the individual tests in the test battery. The most frequent tests are a long jump from a fixed spot (not the five jump), shuttle run 4 x 10m and 30m sprint (but without a turn back, which is part of the Czech 2 x 15m test).

The results of our findings demonstrate significant differences between the fitness levels of the players entering the main part of the season and those indicated by the test results after the first major part of the main season. Improvements are achieved in five of the six tests for the winter testing: running 2 x 15m, dribbling 30m, medicine ball throw, five jump and running 10 x 20m. The only test that revealed a decrease in performance was the Cooper 12 minute run test. As is evident from the following characteristics of handball, this test is not directly related to the nature of the game. Performance in the game of handball is intermittent, with alternating sections of maximal and supramaximal intensity (Chelly et al., 2011; Platen & Manchanda, 2011; Sibila, Vuleta, and Pori, 2004). The mean heart rate in the game is 80–85 per cent of the SF_{max} (Süss and Tuma, 2011), and Chelly et al. (2011) reports approximately 82–85 per cent of the SF_{max} in adolescent handball players. Belka et al. (2014) report a value of over 89 per cent of the SF_{max} . The Cooper 12 minute run test assesses long-term endurance affecting aerobic rather than anaerobic capacity. The training process in handball is specific, and exercises have an interval character with alternating loads of varying intensity.

Currently, it is known that game performance consists of a degree of resynthesis of ATP from aerobic and anaerobic systems (Christmass et al., 1999). Therefore, there is a wide range of metabolic adaptation (Balsom et al., 1995).

The successful management of all game situations seems to require limiting the quality of explosive activity from maximal to supramaximal intensity (anaerobic capacity), which relates to the speed and quality of an individual's playing skills. A player's level of performance depends on the precision of their motor skill learning and appropriate, specific fitness readiness. The aerobic energy gain during repeated maximal intensity intervals with a short recovery time is from eight per cent and progressively increases to 40 per cent; players often reach the level of VO_{2max} (Balsom et al., 1995).

The results of research on aerobic energy gains are still highly contradictory (Hoffman, Epstein, Einbinder and Weinstein, 1999). Authors agree on the need for aerobic capacity during performance in a game, but they do not quite agree on the role of maximal oxygen consumption (VO_{2max}). Alizadeh et al. (2010) similarly found a close relationship between the VO_{2max} and indicators of game performance in players with a low VO_{2max} (mean $37.22 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) but not in players with a medium VO_{2max} level (mean $46.46 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$). Otherwise, a negative correlation was found in players with a high VO_{2max} ($55.63 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$). Similar results were reported by Bishop et al. (2003). They reported that aerobic capacity mainly impacts those processes associated with the removal of H^+ (the reason for low pH) from the plasma, which creates an acidic environment in the muscle, inhibiting superoxide phosphocreatine, which in turn inhibits phosphofructokinase (Edge et al., 2006) and negatively affects the process of muscle contraction (Bishop et al., 2011). The authors prefer to

monitor the speed of re-oxidation during recovery and muscle phosphocreatine resynthesis in relation to game performance and aerobic capacity. Furthermore, they also consider speed to be an important indicator of game performance, but the results imply that we should focus on the players achieving a minimum $\text{VO}_{2\text{max}}$ level instead of planning training to develop maximal $\text{VO}_{2\text{max}}$. This minimal level is approximately 45 ml.kg⁻¹.min⁻¹. Therefore, the application of high intensity interval training (Psotta, 1999) with short operating intervals is optimal for sports games because of the concurrent cultivation of anaerobic capacity and functional motor dispositions for the short-term performance of the simultaneous speed effect on the level of aerobic capacity. Research (Sale, Jacobs, MacDougall and Garner, 1990) supports the claim that extensive aerobic training at continuous low intensity can affect the reduction of muscular strength and power.

In connection with sports games, there are current methods for high intensity intervals with a maximum intensity up to ten seconds and recovery of 60–300 seconds, and high intensity for an intermittent activity with a maximum intensity up to ten seconds and recovery up to 60 seconds. According to Iaia et al. (2009) and Tabata (1996), when comparing high intensity interval training methods and continuous methods of training, the two methods almost identically increased the $\text{VO}_{2\text{max}}$. In addition, high intensity interval method training indicates a significant increase in anaerobic capacity for both glycolytic and enzymatic activity, as well as the ability to restore the acid-base balance and other parameters of anaerobic capacity (Handzel, 2005). Tabata (1996) reported that the increase is up to 28 per cent. Laursen et al. (2002) claim that the differences are even more noticeable in well-trained athletes. The $\text{VO}_{2\text{max}}$ increases only if the player is working with an oxygen debt, and such activities have an intensity higher than 100 per cent $\text{VO}_{2\text{max}}$. Furthermore, reaching a high buffering capacity of the muscle can be increased only in the level of lactate and hydrogen cations in the muscle during training. This can be achieved by high intensity interval training (e.g. 2 x 10 x 2 minutes with 120–140% loading of the anaerobic threshold with one minute of recovery), but it cannot be achieved by continuous methods of low and moderate loads.

When measuring the fitness readiness of players, we should focus more on a player's ability to repeat activity with short maximal intensity for the greatest number of repetitions at the greatest power (to increase the speed and quality of the recovery processes) than on the ability to separately execute the activities at the (supra)maximal intensity or, by contrast, to conduct physical activity with a continuous character as long as possible (Bangsbo et al., 2008). Bangsbo et al. (2006) and Balsom et al. (1995) argue that the number, frequency and duration of an activity in the (supra)maximal intensity or the total distance travelled by a player during a match could be far more valid indicators of the player's fitness than the $\text{VO}_{2\text{max}}$. Therefore, excessive application of aerobic training in basketball and handball players is harmful because the 'player's stamina is something different from aerobic endurance (Bangsbo et al., 2006; Balsom et al., 1995)'. Research (Sale et al., 1990) supports the claim that extensive aerobic training can reduce muscle mass, strength and muscle performance.

Aerobic metabolism is essential both in (supra)maximal intensity activities and during the recovery processes starting immediately after an activity (Tomlin & Wenger, 2001). Research indicates its primary importance is in restoring homeostasis during the recovery interval and during an active phase involving the resynthesis of ATP (Balsom et al., 1995). The quality and degree of timely recovery after acute stress further depends more on the degree of adaptation to the specific type of intermittent physical activity in terms of the intensity profile than on the maximum cardiorespiratory parameters.

Bishop et al. (2003) reported the results of correlating the $\text{VO}_{2\text{max}}$ and repeated sprint ability (RSA) in players. However, this correlation was not confirmed in professional players. Furthermore, the authors found that players who are more responsive to a change in the plasma (due to H^+) have better RSA. In female hockey players, he found that H^+ and not $\text{VO}_{2\text{max}}$ is a predictor of RSA. Thus, although other studies have shown that $\text{VO}_{2\text{max}}$ is important for moderate players, it is not indicative of elite players (Wadley & Le Rossignol, 1998), even though the return of the PC recovery is closely associated with $\text{VO}_{2\text{max}}$.

Buffering capacity is associated with higher performance in RSA. It can increase the player's performance by activating anaerobic glycolysis in the acidic environment in the muscle with low levels of hydrogen ions (Edge et al., 2006). Players who have minor changes in the plasma H^+ in relation to the increase in lactate have better RSA (Edge et al., 2006). According to Edge et al. (2006), intermittent physical activity induces great changes in the concentration of ions and metabolites in the muscles. A high ratio of ATP hydrolysis and glycolysis results in the high accumulation of hydrogen ions (H^+). Such accumulation deteriorates the activation of the muscle contraction and reduces the muscle glycogenolysis that inhibits phosphofructokinase, which leads to fatigue during exercise (Bishop, et al., 2011). There is a correlation between decrease in performance and pH changes in the muscle.

Relationship between the performance and competition level

Several studies have examined the effectiveness of motor test batteries for distinguishing between talented and less talented young athletes. In studies that have focused on this issue, no clear-cut evidence was found with respect to the relevance of the tests (Lidor et al., 2005). For example, Spammers and Coetzee (2002) showed that talented rugby, football, hockey or netball players achieve better overall results than less talented players for different motor, physical and skill tests. However, it can be observed from their analysis that the skill tests distinguish much more easily between the talented and less talented players than the physical and motor tests (Lidor et al., 2005). Our results confirmed the conclusions of Spammmer and Coetzee (2002) and Lidor et al.

(2005), which were also confirmed by our tests showing significant differences in the fitness readiness between talented players playing in the top league (better) and less talented players who play in lower competitions (worse). Pavlovic, Munir, Kazazovic and Lakota (2013) reached the same conclusion when comparing the results of the motor tests of players from the first and second handball divisions in Serbia. The dribbling 30m skill performed in this study—as well as other skills included in a variety of batteries for selection in ball games—is performed individually and in the indoor setting. However, for a handball team, as for other ball games, the players are usually required to perform open skills (Lidor et al., 2005). Open skills require that players anticipate, make decisions, solve problems and evaluate. They have to apply cognitive processes in a constantly changing environment (Schmidt and Wrisberg, 2000). It is well documented in the scientific (e.g. Williams, Davids and Williams, 1999) and applied (e.g. Lidor and Henschen, 2003; NiDeffkh, Sacal, Lowry, and Bond, 2001) literature that top performers in ball games differ from the novices in their ability to understand the game and, accordingly, apply cognitive processes that are related to specific situations in the sport activity. This means that the cognitive aspect of the game may be as important as the physical aspect. If this assumption is true, the selection of a battery should include tests integrating the cognitive components of the game, such as anticipation and problem solving, within the fundamental skills of the game like dribbling, passing and throwing at a goal. Coaches should design open skill testing environments in which players are required to process environmental information, make a decision and solve a problem (Lindor et al., 2005). One of the supporting indicators in the selection of talent should also be anthropometric and physical examination of young players because of possible developmental acceleration or developmental delay. More physically mature players are often promoted at the expense of less physically advanced players, which can have a negative impact on the correct selection of talent in handball. This aspect could be interesting for coaches, who could track the physical development of those players who were not selected among talented players. The players who were late in physical development but demonstrated good skills as part of a handball team might be selected for the team at a later stage (Lindoret al., 2005).

Conclusion

In winter, the players improve in their fitness level compared to that during the summer season. One of the main reasons is that the players between testing periods have undergone a higher volume of training units of specific character and have completed more competitive matches. Accordingly, they improved in all the tests except for one, the Cooper 12 minute run test. Due to the differences in the Cooper 12 minute run test (continuous running) and the training process or individual handball match (intermittent character of running), this test could be replaced by another test in the future, such as the Yo-Yo Intermittent Recovery Test Level 1 or 2.

When comparing results between summer and winter testing, there was an improvement in the younger players in five fitness tests and for older players in only one fitness test. One possible factor may be the age of the players: when they are younger, players undergo more physical development. Another factor that influenced this finding is that younger players up to fifteen years had only three training sessions per week; from fifteen years, the number of training sessions per week rose to five. Increasing the number of training sessions per week in this age group especially affects the fitness of the players.

Peak velocities for different performance qualities occur at different ages and may require age specific training programmes to maximise performance in each age group.

Even though motor tests have gained popularity among Czech handball coaches, we consider the test results insufficiently sensitive to distinguish between talented and less talented players. Furthermore, due to the specificity of a handball game, the tests have their limits. One of the selection criteria for talented players should be skill-specific tests for handball that would monitor the speed, accuracy and creative decisions in a specific game variant. The tests should include shooting and passing precision, movement with and without the ball while changing direction, and defensive manoeuvres.

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