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THE RELATIONSHIP BETWEEN SPEED, STRENGTH AND JUMPING ABILITIES IN ELITE JUNIOR HANDBALL PLAYERS

Jørgen Ingebrigtsen[1] & Ian Jeffreys[2]

[1]*Department of Sports, University of Nordland, Bodø, NORWAY.*
[2]*Department of Science and Sport, University of Glamorgan, Pontypridd, WALES.*

Abstract The present study aimed to examine the relationship between strength (squat and bench press), jumping ability in countermovement (CMJ) and squat (SJ) jump, 10 m and 30 m sprint time and 6x30m repeated sprint ability (RSA) in a group of 29 male elite youth handball players aged 16.5±0.8 years, with stature of 184.3±4.8 cm and body mass of 77.0±9.4, who all voluntarily participated. Coefficients of correlation were determined and tested for significance by using the Pearson's product-moment test. Firstly, sprint time results indicated a significant relationship with jumping height in absolute terms over 0–10 m and 0–30 m ($p<0.01$). When expressed relative to body mass, the 0–10 m sprinting time was found to have a significant relationship with all measures of jump height and peak power ($p<0.01$) in both CMJ and SJ. The 0–30 m sprint time correlated significantly ($p<0.01$) with all jump measures (except jump height assessed by CMJ) relative to body mass. Secondly, repeated sprint ability over 0–10 m correlated to all strength ($p<0.05$) and jumping ($p<0.01$) measures (in absolute terms) except for reactive strength, while 0–30 m RSA only correlated ($p<0.05$) to CMJ and SJ performance. Expressed relative to body mass, the bench press ($p=0.01$), CMJ peak power ($p=0.01$), SJ ($p=0.05$) and SJ peak power ($p=0.01$) significantly correlated to 0–10 m RSA. No other significant results were found. These data suggest that since raw jump scores are relatively easy to collect, they could provide coaches at all levels with valuable information with which to assess speed and overall athletic performance. Also, as power and strength scores only correlated with speed scores when expressed in relation to body mass, it seems important that physical preparation coaches ensure that their force and strength development programs are appropriately adjusted for body mass.

Key words: Speed, repeated sprint ability, countermovement jump, squat jump, handball

INTRODUCTION

Team handball is an international team sport in which two teams of seven players each (goalkeeper and six outfield players) try to throw the ball into the goal of the other team. The sport is played at club, regional and international levels, on a field of 20m x 40m, and the team with the most goals after two periods of 30 minutes wins. A variety of technical skills (such as shooting and passing) and fitness components (e.g. acceleration, jumping and tackling) are necessary to perform at the highest level within team handball [4, 10, 13, 19]. Thus, practitioners and scientists are continuously seeking to identify key factors and characteristics that distinguish between high and low class players [4, 7, 8].

Previous studies on male and female elite and sub-elite team handball players have indicated that strength, jumping abilities and maximal running speed have an impact on performance [10, 12, 13, 26], and that the ability to run and sprint repeatedly at high intensity is of paramount importance for success [15, 17, 23]. These abilities have also been highlighted as important for young team handball players' performance [12, 15, 23]. These parameters therefore need to be appropriately addressed within physical development programs for handball. Although dynamic strength, jumping abilities, speed and repeated sprint ability are considered to be highly interrelated in team handball players [2, 5, 6, 18], only sparse research has focused on the relationship between these physical abilities in elite junior team handball players. Identifying these relationships is paramount for the physical preparation coach as it allows for the determination of commonalities, where complementary methods can be deployed that positively affect a range of parameters. It also allows coaches to identify unrelated areas, which need to be addressed separately within the overall physical development program.

Consequently, the purpose of this investigation was to examine the relationship between strength (squat and bench press), jumping ability (CMJ and SJ), 10 m and 30 m sprint time and 6x30 m repeated sprint ability (mean time) in a group of elite junior handball players.

MATERIALS AND METHODS

EXPERIMENTAL APPROACH TO THE PROBLEM

This study investigated the relationship between strength, jumping ability, speed and repeated sprint ability in elite youth handball players from the northern region of the Norwegian Handball Federation. The participants received a written and verbal presentation of the study with its tests and testing procedures. Having agreed to participate, they were tested within one morning or afternoon session. All tests were carried out at the laboratory of the Department for Sports at University of Nordland, Norway. All players had been tested prior to the experiment to reduce measurement errors caused by learning effects [24].

SUBJECTS

Twenty-nine male elite youth handball players, age 16.5±0.8 years, stature 184.3±4.8, body mass 77.0±9.4 voluntarily participated in this study. All of them were highly committed to team handball, training 9.6±1.6 hours per week; the players were selected by the Norwegian Handball Federation (NHF) as the best players within their age groups (U18 – born 1992, and U16 – born 1994) in the northern region of Norway at the time of testing. Two of the participating players had already represented the Norwegian national U18 and U16 youth teams. This study was conducted during the competitive season. All players, as well as the clubs involved, approved the use of the depersonalized data, and the study was conducted in accordance to the Helsinki declaration. The study was also accepted by the local University Committee.

PROCEDURES

First, the anthropometric measures were taken. The participants' height was measured with a wall mounted stadiometer (KaWe Medizintechnik, Asperg, Germany) and they were weighed on an electronic scale (A&D Company Limited, Tokyo, Japan). The main testing session started with a 15 min general warm up, consisting of running at 70–80% (self-perceived) of maximal heart rate. Next, the participants performed 4–6 accelerations over 20–40 m with increasing effort. A short break was then given for personal preparation. This ensured that they were adequately prepared for maximal efforts.

The testing session was conducted in the following order: the 30 m sprint was tested first, followed sequentially by the CMJ test, the SJ test, the bench press tests, the squat test and finally, the RSA test. Within the sprint, jump, and strength tests, the participants were given three trials separated by at least three minutes of rest to recover. The best performances in each test were chosen for further analysis. Circa 10 minutes recovery was provided between each test.

The sprint and the repeated sprint tests were performed on an indoor court using Brower Speed Trap II timing system (Brower Timing Systems, Utah, USA) with three infrared beams/transmitter sets consisting of an infrared sender (IRD-T175) and an infrared emitter (IRE) with antennas. The equipment was set up on tripods at waist height. During the 30 m sprint test, time was measured for 0–10 m sprint and 0–30 m sprint. This gave a score for initial acceleration (0–10 metres) and full acceleration (0–30 meters). The test-retest reliability of this equipment had previously been shown to be good at both distances (ICC= 0.91 and 0.99 for 0–10 meters and 0–30 meters, respectively) [20]. The participants started from a standing position with their front foot on the starting line. Using a self-start they commenced the sprint, attempting to cover the distance in the shortest time possible. Time count started automatically when the participant broke the beam from the photo cell placed at the starting line. The interval for 0–10 m sprint time was acquired when the participants passed the photo cells at 10 m, and for 0–30 m sprint time when they passed the photo cells at 30 m. CMJ was measured via a force plate (AMTI model OR6-5-1 with an AMTI Model SGA6-3 amplifier). The athletes were instructed to stand on the force plate with hands on hips. From this erect position, with a knee angle of 180 degrees, a counter movement was performed to the athletes' preferred depth (usually a knee angle of approximately 90 degrees), immediately followed by the jump. The SJ tests were started with the participants in a squat position, with a knee angle of 90 degrees, and hands on hips. Without any counter movement, the participants jumped for maximal height. Jumping data were saved to a PC (Pentium 4 with Windows XP) using the Biopack MP 100 software. Peak power and reactive strength scores were later calculated based on CMJ and SJ performances, as previously described by Shalfawi and colleagues [21].

The 1 RM for the bench press and squat strength was determined as a measure of dynamic strength, and the participants progressively increased their resistance over each attempt until 1 RM was reached. Bench press was performed with the participants lying horizontally on the bench with their feet planted on the floor and elbows fully extended to reach the bar (20 kg Olympic and Olympic WL training discs, Eleiko, Sweden) with the grip width approximating their individual shoulder breadth. Next, the bar was lifted off the rack, and the participants lowered the bar in a controlled manner until it touched the chest. Without bouncing the bar from the chest, participants lifted the bar in a self-determined tempo. Squats were performed so that the depth corresponded to a knee angle of 90 degrees approximately. Knee angles were monitored by the same test leader for all subjects to ensure consistency. If the depth required was not achieved, the test was considered unsuccessful.

STATISTICAL ANALYSIS

Raw data were transferred to SPSS 17.0 for Windows for analysis. Correlations were determined by using Pearson's r. Pearson's correlation was computed to observe the relationships between all variables from jumping measures and sprinting times. The 0.05 level of significance was adopted for all statistical tests. A two-way mixed Intra-class Correlation (ICC) reliability and the coefficient of variation (CV) between trials were calculated for all measures in this study according to the guidelines provided by Hopkins [9].

RESULTS

The P-value for all reliability measures was p<0.01. ICC measures of CMJ and SJ were 0.96 and 0.97 respectively, with CV of 4% for CMJ and 3.4% for SJ. The ICC for 0–10 m running speed time was 0.95 (CV=1.1%) and for 0–30 m the ICC was 0.95 (CV=1.1%).

Table 1. Mean values (± SD) for all tests

Variable	Mean ± SD
0—10 m Sprint (s)	1.95 ± 0.09
0—30 m Sprint (s)	4.55 ± 0.21
6 x 0—10 m RSA (s)	1.94 ± 0.09
6 x 0—30 m RSA (s)	4.62 ± 0.66
Squat (1RM)	99.3 ± 25.2
Bench press (1RM)	75.3 ± 15.7
CMJ (cm)	31.3 ± 6.0
Peak power CMJ (W)	3333.9 ± 506.01
SJ (cm)	27.8 ± 5.5
Peak power SJ (W)	3122.1 ± 473.9
Reactive strength (cm)	3.5 ± 2.9

When comparing the results of sprint times with the measures of jump height, peak power and strength in absolute terms, the only significant relationships were found between the scores in jumping height and sprint time over 0–10 m (p<0.01) and 0–30 m (p<0.01) (Table 2). No significant relationships between sprint time (at either 10 m or 30 m) and the measures of strength, peak power and reactive strength were found (p>0.05) (Table 2).

Table 2. The relationship between jump and strength measures and running speed

	Absolute terms				Relative to body mass			
Variable	0—10 m (s)	r^2	0—30 m (s)	r^2	0—10 m (s)	r^2	0—30 m (s)	r^2
Squat (1RM)	-0.054	0.3%	-0.211	4.5%	-0.201	4.0%	-0.334	11.2%
Bench press (1RM)	-0.113	1.3%	-0.267	7.1%	-0.248	6.2%	-0.371	13.8%
CMJ (cm)	-0.627**	39.3%	-0.645**	41.6%	-0.546*	29.8%	-0.430	18.5%
Peak power CMJ (W)	-0.284	8.1%	-0.375	14.1%	-0.605**	36.6%	-0.646**	41.7%
SJ (cm)	-0.690**	47.6%	-0.675**	45.6%	-0.626**	39.2%	-0.586**	34.3%
Peak power SJ (W)	-0.303	9.2%	-0.375	14.1%	-0.654**	42.8%	-0.673**	45.3%
Reactive strength (cm)	0.000	0.0%	-0.067	0.5%	-0.063	0.4%	-0.114	1.3%

Sprint times were also correlated with jump height, strength and peak power relative to body mass. This revealed that 0–10 m sprinting time had a significant relationship with all measures of jump height (CMJ, p<0.05; SJ, p<0.01) and peak power in both CMJ and SJ (p<0.01), but not with any of the strength measures (Table 2). The 0–30 m sprint time had a significant relationship (p<0.01) with all jump scores relative to body mass (except jump height assessed by CMJ), but none of the strength scores (p>0.05).

Repeated acceleration ability (0–10 m) had a significant relationship (p<0.05) with all absolute measures of jump, strength and peak power, except with reactive strength (Table 3). On the other hand, repeated sprint ability over 30 m only had a significant relationship ($p<0.05$) with jump height in absolute terms assessed by CMJ and SJ (Table 3).

Table 3. The relationship between jump and strength measures and repeated sprint ability

	Absolute terms				Relative to body mass			
Variable	0—10 m (s)	r^2	0—30 m (s)	r^2	0—10 m (s)	r^2	0—30 m (s)	r^2
Squat (1RM)	-0.449*	20.2%	-0.369	13.6%	-0.443	19.6%	-0.314	9.9%
Bench press (1RM)	-0.558**	31.1%	-0.300	9.0%	-0.570**	32.5%	-0.133	1.8%
CMJ (cm)	-0.574**	33.0%	-0.462*	21.3%	-0.335	11.2%	-0.096	0.9%
Peak power CMJ (W)	-0.516*	26.6%	-0.310	9.6%	-0.600**	36.0%	-0.184	3.4%
SJ (cm	-0.665**	44.2%	-0.518*	26.8%	-0.527*	27.8%	-0.191	3.7%
Peak power SJ (W)	-0.574**	33.0%	-0.338	11.4%	-0.717**	51.4%	-0.251	6.3%
Reactive strength	0.062	0.4%	0.019	0.0%	0.060	0.4%	0.076	0.6%

When comparing the results relative to body mass, a significant relationship was observed between 0–10 m time and measures of strength assessed by bench press ($p<0.01$) (but not the squat), SJ ($p<0.05$), and peak power ability ($p<0.01$) assessed by both CMJ and SJ (Table 3). Comparing RSA time over 30 m showed no relationship ($p>0.05$) with any measures of strength or jump abilities.

DISCUSSION

The purpose of assessing athletic performance can be identified as help in determining the improvements made by following a training program and examining its effects. However, this has little influence on the direction on which professionals should focus when adapting the training program for subsequent application [3]. Therefore, another purpose of athletic assessment is to point out specific weaknesses in performance and to design programs that address these weaknesses. A part of this process is to identify the complementary aspects of performance and the segments where enhancing one component is likely to positively affect another. Similarly, it is important to distinguish the more independent aspects of performance, which need to be addressed directly in an overall performance enhancement program. In this study, splits were used to measure 10 m and 30 m running speed time as these two aspects of speed performance differ and require different underpinning physical capacities. Splits were also used in measuring 0–10 m RSA and 0–30 m RSA to identify whether these also were different capacities. This allowed for an independent analysis of the distances and a presentation of the relationship for each of the distances with measurements of strength and jump performance.

A key factor in the optimal evaluation of the relationship between performance parameters is the reliability of measurements enabling appropriate data analysis. The ICC reliability analyses indicated a high repeatability between the trials. The variations between trials assessed by CV were lower than 5% for all scores, which indicated little variation [9]. This is supported by other studies which have found that reliability for SJ, CMJ and sprint measures can be achieved without the need for familiarization sessions with physically active men [16]. This demonstrates a high reliability in the data, and allows for appropriate analysis of the results.

The Relationship Between Running Speed and Measures of Jump Height, Maximum Strength and Peak Power

Handball performance is multifaceted, and relies on the development of a wide range of physical capacities. Speed is seen as a key component of elite performance in handball, and identification of factors that relate closely to running speed can assist the coach in the development of complementary training programs. The results of this study also indicate that there were significant relationships between all scores for running speed and jumping height in absolute terms (Table 2). This suggests that the training methods capable of enhancing jump height will assist in the development of running speed. However, no measures of power in absolute terms significantly correlated with running speed (Table 2). The same results were previously detected by Baker & Nance [1], as they found that there was no relationship between running speed and power in absolute terms. This suggests that when looking at athletic performance, raw jump scores may be of more value to the practitioner than measurements of absolute power. This finding would be of great use to the coach without access to sophisticated equipment, as simple jump scores may be an appropriate indicator of speed performance. Similarly, it would remove the need to convert jump scores to a measure of power, which may be unrelated to success in jumping and sprinting sports [11].

If power scores are to be used, they should be related to body mass, as measures of power relative to body mass assessed during CMJ and SJ were significantly related to sprint performance (Table 3). This is not unexpected, as sprinting involves high and rapid force production, all directly related to propelling the body mass at maximal velocity. In support of these findings, Young et al [25] reported that measures of power relative to body mass were most likely to correlate to sprint performance, irrespective of the distance. The same was found by Baker & Nance [1] and McBride et al [14]. The highest correlation for the start and acceleration speed (0–10 m) was with jump height in absolute terms which was assessed through SJ ($r = -0.690$), with a variance of 47.6% as set by the coefficient of determination. This could be explained by the concentric contraction-only nature of the squat jump. Young and colleagues [25] concluded that the best predictor in their study regarding sprinting performance was jumps performed through concentric contraction such as SJ, while the measures produced by SSC such as CMJ resulted in relatively low correlation. This would corroborate with the findings that initial acceleration speed is related closely to concentric abilities and that, as maximal speed is approached, the SSC capacities gain in importance [25]. Again the higher correlations with jump scores demonstrate the usefulness of raw jump data, without the need to revert to peak power measures.

The major findings of this study with regard to the repeated sprint ability were that significant relationships were observed between RSA over 0–10 m and strength measures, jumping height and peak power in absolute terms. Thus in this group of athletes, RSA was more closely related to strength and absolute power than maximal speed. Similar results were reported by Young and colleagues [25] and Sleivert and Taingahue [22]. Furthermore, a marked relationship was observed between 10–30 m RSA and the measures of jumping height. However, no relationships were observed between 0–30 m RSA and any of the strength, jump height, peak power or reactive strength scores. Clearly, the relationship differs between the longer RSA distances and measures of strength and jump ability. This suggests that factors contributing to performance over these distances may be quite different, and may need to be addressed separately within the program. Thus, training to improve RSA over these distances may involve different training methods to some extent [1, 25].

CONCLUSION AND PRACTICAL APPLICATION

Correlations are limited to shedding light on associations rather than answering questions related to cause and effect. Therefore, the readers are urged to have this limitation in mind when reading the practical applications suggested herewith. However, the results do provide important information with which to guide effective practice.

It would appear that the most effective predictors of sprint performance in elite junior handball players at both 10 and 30 meters were raw jump scores. With modern technology allowing for the measurement of a range of force parameters, the present data suggest that raw jump scores should not be overlooked in favor of more technical scores such as peak power. Raw jump scores are relatively easy to collect and therefore could provide coaches at all levels with valuable data with which to assess speed and overall athletic performance. Therefore, these results can be used to effectively predict speed performance. Additionally, training methods aimed at enhancing jump height (both SJ and CMJ) are likely to assist in the development of running speed. If peak power scores were to be used as predictors of performance, these should be considered in relation to body mass.

While Newtonian laws would suggest a close relationship between strength and speed, this was not found in this study. Thus, the development of absolute strength itself will not maximize speed development. The results suggested that initial acceleration was more closely linked to SJ scores and that consequent acceleration was correlated with CMJ scores. This suggests force specificity to these two abilities, and requires that each capacity be addressed during a speed development program. These will require specific training inputs to address each component.

An important finding was that power and strength scores only correlated with speed scores when expressed in relation to body mass. Therefore, it is important that physical preparation coaches ensure that their force development programs make an appropriate adjustment for body mass, and that the strength-to-mass ratio is a key factor considered in the development of appropriate physical abilities in handball players. The results also demonstrate that repeat sprint ability is related to strength measures, both relative and absolute. In this way, strength plays an important role in the ability to repeat sprint bursts and needs to be developed, in addition to traditional metabolic conditioning, when aiming to maximize repeat sprint ability.

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Address for correspondence:

Jørgen Ingebrigtsen
Centre for Practical Knowledge
Department of Sports
University of Nordland
8049 Bodø, NORWAY
Phone +47 75517945
Fax +47 75517570
E-mail: jorgen.ingebrigtsen@uin.no

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