Technical Match Characteristics and Influence of Body Anthropometry on Playing Performance in Male Elite Team Handball

Lars Bojsen Michalsik,[1,2] Klavs Madsen,[3] and Per Aagaard[2]

[1]Department of Public Health, Section of Sport Science, Aarhus University, Aarhus, Denmark; [2]Institute of Sport Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark; and [3]Department of Food and Nutrition, and Sport Science, University of Gothenburg, Gothenburg, Sweden

Abstract

Michalsik, LB, Madsen, K, and Aagaard, P. Technical match characteristics and influence of body anthropometry on playing performance in male elite team handball. *J Strength Cond Res* 29 (2): 416–428, 2015–Modern team handball match-play imposes substantial physical and technical demands on elite players. However, only limited knowledge seems to exist about the specific working requirements in elite team handball. Thus, the purpose of this study was to examine the physical demands imposed on male elite team handball players in relation to playing position and body anthropometry. Based on continuous video recording of individual players during elite team handball match-play (62 tournament games, ~4 players per game), computerized technical match analysis was performed in male elite team handball players along with anthropometric measurements over a 6 season time span. Technical match activities were distributed in 6 major types of playing actions (shots, breakthroughs, fast breaks, tackles, technical errors, and defense errors) and further divided into various subcategories (e.g., hard or light tackles, type of shot, claspings, screenings, and blockings). Players showed 36.9 ± 13.1 (group mean ± *SD*) high-intense technical playing actions per match with a mean total effective playing time of 53.85 ± 5.87 minutes. In offense, each player performed 6.0 ± 5.2 fast breaks, received 34.5 ± 21.3 tackles in total, and performed in defense 3.7 ± 3.5 blockings, 3.9 ± 3.0 claspings, and 5.8 ± 3.6 hard tackles. Wing players (84.5 ± 5.8 kg, 184.9 ± 5.7 cm) were less heavy and smaller ($p < 0.001$) than backcourt players (94.7 ± 7.1 kg, 191.9 ± 5.4 cm) and pivots (99.4 ± 6.2 kg, 194.8 ± 3.6 cm). In conclusion, modern male elite team handball match-play is characterized by a high number of short-term, high-intense intermittent technical playing actions. Indications of technical fatigue were observed. Physical demands differed between playing positions with wing players performing more fast breaks and less physical confrontations with opponent players than backcourt players and pivots. Body anthropometry seemed to have an important influence on playing performance because it is highly related to playing positions. The present observations suggest that male elite team handball players should implement more position-specific training regimens, while also focusing on anaerobic training and strength training.

Key Words technical match analysis, physical confrontations, positional differences, player characteristics, impaired physical performance, orthopometric measurements

Introduction

Team handball (TH) is a physically demanding team sport with professional leagues in a large number of countries, and major international championships are held regularly. During the 60 minutes of match-play (30 minutes each half with a 15-minute half-time break), the players work intensely for short, intermittent time intervals, while frequently performing different types of locomotion and technical match activities, e.g., powerful upper-body movements such as maximal ball throwing (i.e., shots on goal) and tackles of opponents as well as forceful lower limb muscle actions during vertical jumping, sideways running, backward running, forward sprinting, and changes of direction with a high number of physical confrontations with opponent players, where they concurrently continuously must be aware of the tactical game conditions (6,9).

Although the game of TH is more than a century old, it has continued to develop over the years, leading to increased physical and technical demands on elite players. In addition, increased frequency and intensity of training and match-play have contributed to increase the physical demands imposed on high-level players, and in the last decade, new rules (e.g., quick throw-off) have made the game even faster and more intense (16). To develop optimal training regimens for elite TH players, it is necessary to conduct a complete working demand analysis of the game because knowledge of the

Address correspondence to Lars Bojsen Michalsik, lbmichalsik@health.sdu.dk.

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working requirements is a prerequisite for the planning and implementation of optimal training paradigms (6).

Team handball match-play involves a large number of other physical activities besides running. Tackles, shots, fakes, blockings, and side-cuttings are all examples of technical playing actions that are inherent in modern TH, but these factors and their relative share of the total working demands are not well documented. A complete physical working demand analysis includes locomotion match analysis (movement category, intensity, and distance) complemented by technical match analysis (technical playing actions) (10). The exclusion of either of these analyses will give rise to a systematic underestimation of the working demands of the game.

Unlike other team ball sports, surprisingly little knowledge exists about the physical demands in TH and the physiology of elite TH players. To the best of our knowledge, no data have been published on technical playing actions in male elite TH. Consequently, there is a profound need for a thorough scientific examination of the physical demands of modern elite TH match-play, not only to identify the physical requirements of present-day elite players but also to provide a more individualized basis for physical training design. Virtually all studies of physical working demands in ball games have focused exclusively on the locomotion analysis of players during match-play. Because TH involves a great deal of physical contact and other technical playing actions, technical match analysis was conducted in this study to avoid underestimation of the quantity of movement. A separate analysis of the same matches in the present group of players that comprised locomotion match characteristics was also performed, as reported elsewhere (9).

Although seeming an obvious fact from the world of practice, no previous investigation has examined whether differences in physical demands exist between various playing positions in modern elite TH. If so, physical training should be more carefully individualized rather than involving a traditional and uniform training regime for all players on the team. Furthermore, it remains unknown whether the performance of elite TH players is impaired during match-play because of temporary onset of fatigue. Such information appears highly relevant when planning and executing physical training in modern elite TH. Finally, it also seems to be of high relevance to examine the body anthropometry of elite TH players because previous studies (1,14,22) have indicated that body anthropometry (body mass [BM] and body height [BH]) may have important influence on playing performance in male elite TH. However, this aspect has not been previously examined fully in relation to specific playing positions.

The aims of this study, therefore, were (a) to examine and characterize the physical demands imposed on male elite TH players during match-play, (b) to identify positional differences in physical demands and body anthropometry, and (c) to examine to what extent physical match performance can be sustained during elite TH match-play. Because substantial differences in activity patterns may occur from team to team and match to match and between players of different playing positions, respectively, this study included a large sample of players from various teams representing all playing positions from the Danish Premier Male Team Handball League that is considered to be among the top-leagues in international male TH.

Because of the complexity and high intensity of the TH game, we hypothesized that (a) male elite TH players would demonstrate a high capacity for a wide range of technical qualities including tackles and screenings, jump shots, and rapid directional changes during fast breaks, (b) physical demands and body anthropometry would differ between playing positions, and (c) signs of match-induced fatigue would emerge during match-play.

Methods

Experimental Approach to the Problem

This study comprised technical match analysis and anthropometric measurements in Danish male elite TH players during the entire tournament match season (September to May, with players performing 6–10 training sessions and 1–2 matches per week). The analyzed matches were performed indoor under thermoneutral conditions in terms of temperature (18–22° C) and humidity (50–70%). Activity patterns of goalkeepers differ considerably from those of field players. For this reason, the physical demands placed on goalkeepers were not examined in this study. Observations during match-play took place by means of video recordings of 62 tournament matches in the Danish Premier Male Team Handball League, including semi-finals and a final of the Danish National Championship. The intensity of the matches was, therefore, representative of the level of playing intensity in male elite TH. One designated camera captured one player close up continuously without interruption throughout the entire time course of the match (about 4 field players per match). Thus, a total of 240 single player recordings were performed. The videotapes were later replayed on a monitor for computerized coding of the activity pattern of each player fulfilling the inclusion criteria.

Because of substitutions, the effective playing time for each individual player varied from match to match. Defense and offense substitutions were also carried out, which led to large differences in individual player's time on-court in defense and in offense, respectively. In addition, some players were changing playing position on the court during match-play. To arrive at a realistic picture of a TH player's performance during match-play and to achieve analytic comparability between different playing positions, it was necessary to establish certain inclusion criteria with respect to minimum playing time on the court.

Because TH rules, in contrast to soccer for example, allow unlimited substitutions of players throughout the entire match, it was not possible to collect adequate individual data for a full match time of 60 minutes. Conversely, we

aimed to only include players with sufficiently long field playing time, to ensure that their activity pattern would reflect the true overall physical demands of the game. In accordance with previous reports (9), the inclusion criteria were determined as being an effective on-count playing time for the whole match of 42 minutes or more (i.e., ~70% of total effective match duration) with an effective on-count playing time in each half-time period of 18 minutes or more (i.e., ~60% of total effective duration of one half). In case of substitution or injury to a player causing a substantial reduction in playing time, the recording was excluded from the investigation. A total of 82 recordings fulfilled these conditions and were analyzed according to the established criteria (9).

The players examined in the present study on average played roughly 1 tournament match per week during the regular tournament match season (Danish National Championship), which is much different from the conditions of national team players when participating in international male elite TH tournaments, where each team typically play about 10 matches in 12–14 days (16). In such tournaments, players tend to be more frequently substituted on all playing positions, especially for backcourt players and pivots (9), to maintain or to limit a decrease in physical playing performance during the time course of the tournament. In addition, for mainly tactical reasons, some players rotate between every ball possession, i.e., some players specializes to play in offense only, whereas others play only in defense. However, only a limited number of specialized players were observed in the present study. This is probably because, at the club level, the best players mostly will have to take part in both offense and defense because of a less homogenous playing standard (fewer top performing players) among the players of the team. Consequently, the mean playing time for first-choice players was often high, with limited playing time for all other players.

Players with greatly reduced on-court playing time were not examined in this study, because such players (playing for 15 minutes) are more likely to show an atypically high playing intensity compared with players, who are involved for longer durations of the game. If the specialized or substituted players with short playing time were included, the average results would probably show a different picture of the activity pattern of elite TH players.

A recent Portuguese study (14) aimed to determine the physical demands in male elite TH by collecting data from the playing position and not from individual players. Thus, when a player was substituted, the substitute on the same playing position was recorded. However, the average result from the playing position (60 minutes playing time) will then depend highly on the substitution frequency because substituted players might show an atypically high playing intensity. A higher number of substituted players on the specific playing position most likely would lead to a higher amount of playing actions. Consequently, with this experimental approach, it becomes difficult to compare player activity patterns within the same playing position and also between different playing positions unless a comparable substitution time and frequency is used for all positions. Therefore, by using this procedure, the average results are not likely to reflect the actual demands for elite players during TH match-play.

Furthermore, anthropometric data (BM and standing BH) and relevant player characteristics (e.g., preferred playing position and playing experience) were obtained in all players from the Danish Premier Male Team Handball League.

Subjects

Elite TH players from the Danish Premier Male Team Handball League including the 2 top ranked teams were recruited as experimental subjects in the study. A number of the players were competing in the European TH Champions League, and several players were also playing at their respective national teams, hence representing multiple nations. The players were examined over a 6-year period during which all participants played on teams ranked in the upper half of the Danish Premier Male Team Handball League. No year-to-year differences were observed during the 6-year study period for any of the analyzed parameters.

All players were fully informed about the experimental procedures and possible discomforts associated with the study before giving their written informed consent to participate. The conditions of the study were approved by the local ethics committee. The study was conducted in accordance with the principles of the Declaration of Helsinki. A number of different teams were monitored in this study, with new players joining individual teams, whereas other players were leaving the teams during the 6-year study period. A total of 32 individuals players on the teams studied met the inclusion criteria (mean number of recordings per player: 2.6, range: 1–7).

Procedures

Observations During Match-Play—Video Recordings. The tactical/technical demands differ markedly between offense and defense during TH matches. Therefore, the present computerized technical match analysis focused separately on offensive and defensive technical playing actions. The team of the player, that was analyzed, was defined to be in offense, when the opponent team lost the ball or, when the opponents finished an attack by a shot, and the analyzed player's team came in possession of the ball. Conversely, the team was defined to be in defense, when the team lost the ball or finished an attack by a shot, and the opponent team came in ball possession. Field players were divided into 3 categories in both offense and defense: wing players (WP), pivots (PV), and backcourt players (BP). Normally, a WP in offense will also be the WP in defense (wing defense), and a BP (including the center backcourt player or playmaker) will also be the BP in defense (back defense). Furthermore, a PV will normally be the PV in defense (middle defense). However, a few players changed position on the court, e.g., playing WP in offense and BP in defense.

A complete technical match analysis has not previously been performed in elite TH, because of which a specific analysis program for the technical match analysis in TH was developed (11). A total of 6 types of technical playing actions (tackles, breakthroughs, fast breaks, shots, technical errors, and defense errors) were defined and continuously registered throughout the entire game. Each playing action was further divided into a number of subcategories (e.g., hard or light tackles, type of shot performed, claspings, screenings, and blockings), all of which were precisely defined according to standard descriptions of technical playing notions in team handball match-play. A few playing actions occasionally overlapped, e.g., a breakthrough could result in a technical error, in a shot or in a tackle of a special category. In this way, some player activities were registered in several categories, because of being split into different playing actions. Players, who regularly changed defensive position making it impossible to define a fixed defensive playing position, were excluded from the analysis of defensive playing actions. The number of physical confrontations was quantified by registering all tackles, screenings, claspings, and blockings, i.e., by identifying all technical playing actions that involved physical contact between players.

During the process of analysis, the observer viewed the TH match on a video monitor and concurrently registered each technical playing action by allocated key strokes on the keyboard of the computer. By continuously following and assessing the separate actions during the match on the video monitor, these actions could constantly be registered by the designated software. Likewise, each time there was a change in the action of the player on the court, a corresponding entry on the keyboard was made. The entered data were continuously processed by the custom-made computer software (11).

To ensure high data reliability, all matches in this study were analyzed by the same experienced observer. A similar approach has been used in previous studies (9,13,20). The first and the second half of each match were analyzed separately in a randomized order. Importantly, the observer had to meet certain adaptation criteria before initiating the analysis. This was achieved by conducting an intense practice period with studies of individual players' styles of locomotion and technical activity pattern. In addition, several validation tests were performed for each

Table 1. Offensive and defensive playing actions per match (group mean ± *SD*) for all players combined and for the different playing positions.*

	Positional differences			
	All players combined ($n = 82$)	Wing players ($n = 23$)	Pivots ($n = 18$)	Backcourt players ($n = 41$)
Playing actions	Number per match	Number per match	Number per match	Number per match
Offensive actions in total for the entire match				
Playing time (min)	26.18 ± 3.13	26.52 ± 3.55	26.12 ± 2.68	26.02 ± 3.10
Offensive breakthroughs	1.5 ± 1.4	1.2 ± 1.2	1.0 ± 0.5	1.8 ± 1.3
Fast breaks	6.0 ± 4.2	8.9 ± 3.1*	8.3 ± 4.0	3.4 ± 3.2π
Technical errors	1.5 ± 1.3	1.2 ± 0.9	1.6 ± 1.2	1.5 ± 1.7
Hard tackles	7.5 ± 4.4	4.3 ± 2.1*	11.6 ± 3.2#	7.5 ± 2.7π
Light tackles	27.0 ± 18.4	10.6 ± 2.3*	58.9 ± 20.3##	22.2 ± 10.0ππ
Claspings	2.7 ± 1.9	1.2 ± 0.9	6.1 ± 2.9##	2.1 ± 1.5ππ
Screenings	4.8 ± 8.3	0.4 ± 0.7*	16.7 ± 9.6##	2.2 ± 4.3ππ
Shots	8.5 ± 4.2	6.0 ± 2.5***	7.0 ± 2.0	10.5 ± 3.4π
Scoring percentage	44.9 ± 17.7	46.9 ± 23.9	48.8 ± 24.2	42.0 ± 14.6
Defensive actions in total for the entire match				
Playing time (min)	27.67 ± 4.18	26.28 ± 2.40*	27.08 ± 2.42	28.70 ± 2.80
Hard tackles	5.8 ± 3.6	4.9 ± 3.3	6.6 ± 3.2	6.0 ± 3.3
Light tackles	24.1 ± 12.6	14.6 ± 5.9*	33.7 ± 12.4##	25.2 ± 7.3π
Claspings	3.9 ± 3.0	1.3 ± 1.1**	8.2 ± 5.0##	3.5 ± 2.0π
Screenings	6.1 ± 3.1	0.9 ± 1.5****	12.4 ± 7.4##	6.3 ± 3.7π
Blockings	3.7 ± 3.5	0.2 ± 0.4****	5.5 ± 3.2##	4.9 ± 2.8
Defensive errors	3.8 ± 2.5	3.0 ± 2.2	5.4 ± 1.8#	3.7 ± 2.3

*Difference between wing players and backcourt players *$p \leq 0.05$, **$p < 0.01$, ***$p < 0.005$, and ****$p < 0.001$; between wing players and pivots #$p \leq 0.05$ and ##$p < 0.001$; and between pivots and backcourt players π$p \leq 0.05$ and ππ$p < 0.001$.

player according to the predetermined categories of technical match activities.

Sufficient competence of the analyst was considered to be reached when data from successive analysis of given periods of the same match differed by less than 3% in each of the technical playing actions. The validation tests also included a test-retest analysis of 15 matches, which were randomly selected. The 2 analyses were separated by at least 3 months. Thus, no systematic differences in the final intra-observer test-retest analysis outcome were observed (ICC $>$ 0.90) after the period of analyst training. Compared with the locomotion match analysis (9), it was easier to attain high reproducibility at the technical match analysis, because the technical playing actions were easier to assess accurately and occurred with a significantly lower frequency.

Body Anthropometry. Anthropometric data (BM and standing BH) were recorded in all players from the 2 top ranked teams ($n = 26$) during physical tests sessions. In addition, body anthropometry and player characteristics were obtained for the remaining teams of the Danish Premier Male Team Handball League by the team physician or physiotherapist and were subsequently reported to the principal author in the first season ($n = 157$) and in the fifth season ($n = 191$). Specifically, information about the individual players' BM, BH, age, playing position, player choice (first or second choice), and playing experience (years of playing) at the adult elite level were obtained.

Body mass was measured with the players wearing light indoor clothing (short pants and t-shirt) and no shoes, using commercially available electronic digital scales (measurement error $\leq$ 1%) that were routinely used and maintained (calibrated) by the medical staff of the involved clubs. During all laboratory tests, BM was measured using a Tanita Body Composition Analyzer (TBF-3000; Tanita Corporation, Tokyo, Japan, measurement error $\leq$ 0.5%). Standing BH was also measured by the medical staff to the nearest millimeter using a wall-mounted stadiometer with players positioned in an erect posture against a wall without socks and shoes or in some cases using a portable stadiometer (Leicester Portable Height Measure; Seca, Hamburg, Germany) (measurement error $\leq$ 1 mm, corresponding to $\leq$0.05% relative error).

Statistical Analyses. All statistical analyses were conducted using R2 Version 13.1 (University of Auckland, New Zealand). All

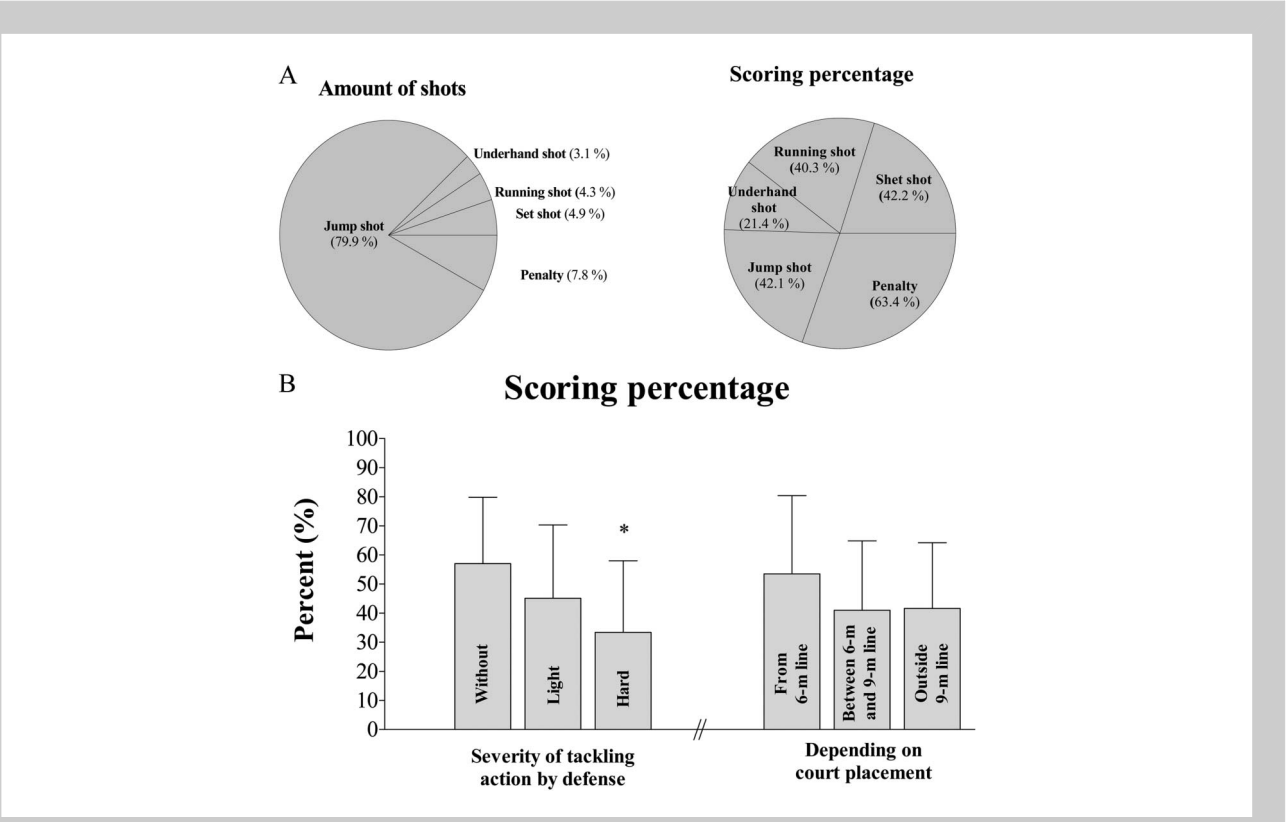

Figure 1. A) Distribution of shots and scoring percentage for backcourt players ($n = 41$). B) Scoring percentage in relation to corresponding defense action of opponents, i.e., whether players received a hard tackle, a light tackle, or no tackle ($n = 82$) (left panel) and scoring percentage in relation to players' position on the court (where the take-off is carried out)—from the 6-m line, between 6-m and 9-m line, and outside the 9-m line ($n = 41$) (right panel). Results are group mean $\pm$ *SD*. Difference between scoring percentage without a tackle and scoring percentage with a hard tackle $^*p \leq 0.05$.

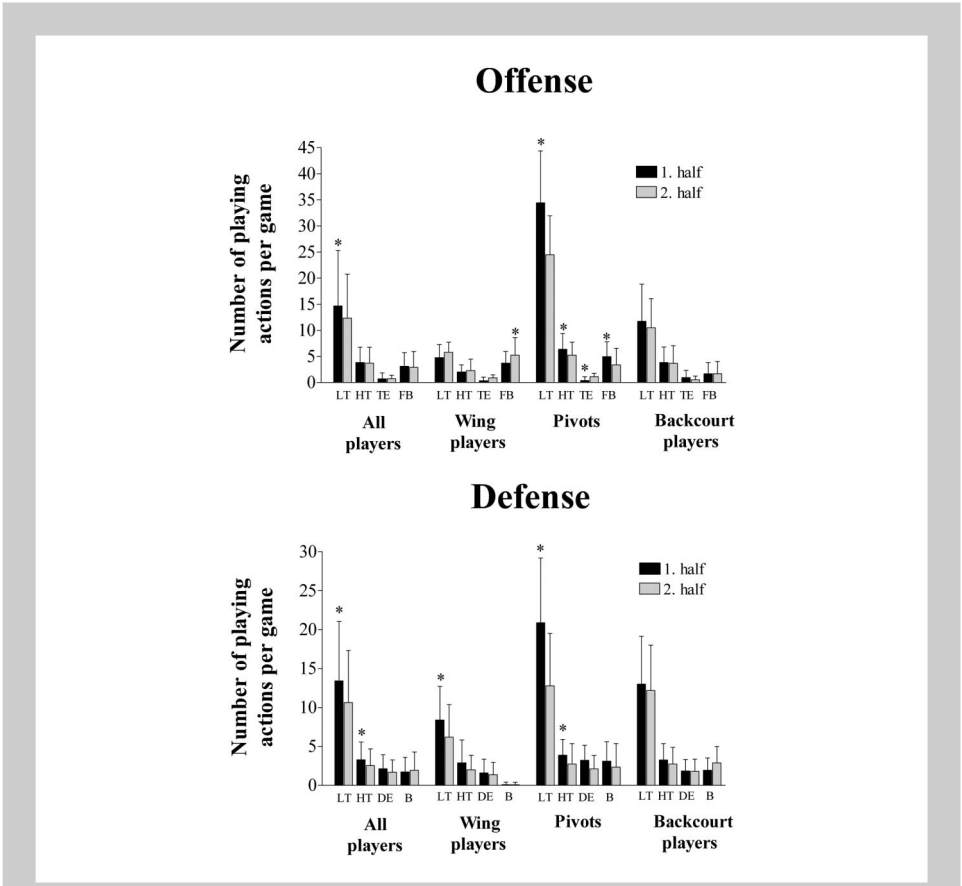

Figure 2. Number of selected playing actions in first and second halves of Danish Premier Male Team Handball League tournament matches for players in offense (top panel) and in defense (lower panel) for all players combined ($n = 82$) and in relation to different playing positions. Results are group mean ± *SD*. Difference between the first and the second half *$p \leq 0.05$. HT = hard tackles; LT = light tackles; TE = technical errors; FB = fast breaks; DE = defensive errors; B = blockings.

results are presented as group mean values ± *SD* unless otherwise stated. Assumption of a Gaussian distribution of data was examined and visually verified using QQ-plots. When 2 normally distributed parameters were compared within the same group of subjects (e.g., differences between first and second half), Student's paired *t*-test was used. Student's nonpaired *t*-testing was used to compare nonmatched subject groups (e.g., differences between first- and second-choice players). The assumption about similar variance was tested using residual plots.

Between-group comparisons (i.e., comparing different playing positions) were evaluated using one-way analysis of variance. Post hoc differences between groups were evaluated by Tukey's HSD testing (normally distributed). Potential relationships between selected outcome parameters were evaluated using Pearson product-moment correlation analysis. Cohen's *d*-test was used to calculate effect size (*d*-values denoted as ES) to estimate the magnitude of the results (differences between subjects or groups) and were reported along with all statistically significant results as an indicator of practical significance. The level of statistical significance was set at $p \leq 0.05$ (2-tailed test design).

Results

Duration of Games and Effective Playing Time

Excluding the half-time break, the total duration of the tournament games examined in this study ($n = 62$) averaged 78.90 ± 2.02 minutes corresponding to 31.5% extension compared with the normal match total effective playing time of 60 minutes (30 minutes each half). This was due to brief match pauses during e.g., suspensions, penalties, and injuries in addition to the time-outs taken by the coaches (2 in each half of 1 minute each). The full duration of the second half (40.70 ± 1.82 min) was longer than that of the first half (38.20 ± 1.52 min) ($p \leq 0.05$, ES = 1.49), which corresponded to an extension of 27.3 and 35.7%, respectively, relative to the nominal playing time of 30 minutes. The mean total effective playing time for the players analyzed in this study ($n = 82$) was 53.85 ± 5.87 minutes. No difference in the mean total effective playing time was observed between defense (27.67 ± 4.18 min) and offense (26.18 ± 3.13 min), between the first (27.20 ± 2.42 min) and the second half of the match (26.65 ± 2.45 min), or between the different playing positions (WP: 52.80 ± 5.40 min, PV: 53.20 ± 6.18 min, BP: 54.72 ± 5.52 min).

Technical Match Analysis

When in offense, each player performed 6.0 ± 5.2 fast breaks and 8.5 ± 4.2 shots per match with a scoring percentage of 44.9 ± 17.7, while performing 5.8 ± 3.6 hard tackles in the defense (Table 1). Technical actions differed between playing positions. Wing players showed markedly less body contact with opponent players than BP and particularly PV (Table 1). In offense, WP received less tackles in total (hard and light tackles) per match (14.9 ± 3.6) than PV (70.5 ± 22.7, $p < 0.001$, ES = 3.42) and BP (29.8 ± 16.1, $p \leq 0.05$, ES = 1.28) and performed less screenings (0.4 ± 0.7) than PV (16.7 ± 9.6, $p < 0.001$, ES = 2.39) and BP (2.2 ± 4.3, $p \leq 0.05$, ES = 0.58). Furthermore, WP (8.9 ± 3.1, $p \leq 0.05$, ES = 1.75) and

Table 2. Age, body height, body mass, and adult elite playing experience (group mean ± *SD*) for all players combined and for the different playing positions (inclusive goalkeepers), respectively, in the 2 top ranked teams and in the entire Danish Premier Male Team Handball League in the first season.*

Body anthropometry	Age (y)	Body height (cm)	Body mass (kg)	Adult elite playing experience (y)
The 2 top ranked teams				
All players combined ($n = 26$)	26.2 ± 3.1	188.9 ± 5.3	90.9 ± 9.0	7.1 ± 3.4
Wing players ($n = 9$)	24.9 ± 2.6	185.8 ± 5.3	80.9 ± 5.5**	5.9 ± 2.4*
Pivots ($n = 7$)	27.7 ± 2.3***	194.7 ± 2.1#	101.4 ± 8.3#	7.7 ± 3.2
Backcourt players ($n = 7$)	26.2 ± 3.4	187.0 ± 6.4	91.7 ± 6.7	7.2 ± 3.9
Goalkeepers ($n = 3$)	26.8 ± 2.4	188.7 ± 5.5	94.3 ± 6.8	8.8 ± 3.7
The entire Danish Premier Male Handball League in the first season				
All players combined ($n = 157$)	26.5 ± 5.0	188.7 ± 6.1	90.5 ± 7.9	7.3 ± 2.8
Wing players ($n = 32$)	25.0 ± 2.3*	183.1 ± 5.0*	82.0 ± 5.5*	5.8 ± 2.6*
Pivots ($n = 27$)	26.8 ± 3.2	192.0 ± 4.9	95.1 ± 7.1	7.5 ± 3.2
Backcourt players ($n = 67$)	26.7 ± 2.8	189.4 ± 5.8	91.2 ± 6.2	7.7 ± 3.3
Goalkeepers ($n = 26$)	27.5 ± 3.0	191.4 ± 4.8	93.8 ± 7.3	8.5 ± 4.3

*Difference between wing players and all other playing positions *$p \leq 0.05$ and **$p < 0.001$; between wing players and pivots ***$p \leq 0.05$; and between pivots and all other playing positions #$p \leq 0.05$.

Table 3. Age, body height, body mass, and adult elite playing experience (group mean ± *SD*) for first-choice and second-choice players for all players combined and for the different playing positions (inclusive goalkeepers), respectively, in the entire Danish Premier Male Team Handball League in the fifth season.*

	The entire Danish Premier Male Team Handball League in the fifth season			
	Difference between first-choice and second-choice players			
Body anthropometry	Age (y)	Body height (cm)	Body mass (kg)	Adult elite playing experience (y)
All players combined ($n = 191$)	26.0 ± 4.4	190.3 ± 6.1	92.6 ± 8.5	7.3 ± 4.4
First choice ($n = 105$)	27.1 ± 3.9####	190.6 ± 6.6	92.9 ± 8.2	8.4 ± 3.7####
Second choice ($n = 86$)	24.7 ± 4.6	189.9 ± 5.5	92.3 ± 8.9	6.0 ± 4.0
Wing players ($n = 52$)	24.9 ± 3.9**	184.9 ± 5.7*	84.5 ± 5.8*	6.5 ± 4.0**
First choice ($n = 30$)	26.4 ± 3.6####	184.2 ± 6.1	84.3 ± 5.5	7.9 ± 3.7###
Second choice ($n = 22$)	22.7 ± 3.3	185.8 ± 5.1	84.7 ± 6.1	4.5 ± 3.6
Pivots ($n = 33$)	26.2 ± 5.0	194.8 ± 3.6π	99.4 ± 6.2ππ	7.4 ± 5.2
First choice ($n = 20$)	26.6 ± 3.8	195.1 ± 3.9	98.9 ± 5.2	7.9 ± 2.1
Second choice ($n = 13$)	25.6 ± 4.3	194.7 ± 3.4	100.4 ± 7.5	6.6 ± 3.5
Backcourt players ($n = 80$)	25.8 ± 3.6	191.9 ± 5.4	94.7 ± 7.1	7.3 ± 3.9
First choice ($n = 42$)	26.9 ± 3.1###	192.7 ± 5.2	95.7 ± 5.8	8.4 ± 3.4###
Second choice ($n = 38$)	24.5 ± 3.8	190.9 ± 5.5	93.2 ± 8.1	5.9 ± 4.1
Goalkeepers ($n = 26$)	28.5 ± 5.6***	190.8 ± 4.2	94.1 ± 7.9	9.5 ± 5.4
First choice ($n = 12$)	30.2 ± 4.3##	191.8 ± 4.9	94.2 ± 9.1	11.0 ± 3.3#
Second choice ($n = 14$)	27.0 ± 3.2	190.0 ± 3.4	94.0 ± 7.0	8.0 ± 4.1
Danish players ($n = 163$)	25.6 ± 4.4€€	190.1 ± 6.0	92.0 ± 8.2€	7.0 ± 4.2€€€
Foreign players ($n = 28$)	27.9 ± 3.9	191.6 ± 6.9	96.1 ± 9.8	9.6 ± 4.2

*Difference between wing players and all other playing positions *$p < 0.001$; between wing players and goalkeepers **$p \leq 0.05$; between goalkeepers and backcourt players ***$p \leq 0.05$; between pivots and all other playing positions $\pi p \leq 0.05$ and $\pi\pi p < 0.01$; between first-choice and second-choice players #$p \leq 0.05$, ##$p < 0.01$, ###$p < 0.005$, and ####$p < 0.001$ as well as between Danish and foreign players €$p \leq 0.05$, €€$p < 0.01$, and €€€$p < 0.005$.

Table 4. Age distribution (group means) for all players combined and for the different playing positions (inclusive goalkeepers) in the entire Danish Premier Male Team Handball League in the fifth season.

Age distribution			
The entire Danish Premier Male Team Handball League in the fifth season			
	Under 23 years (%)	Between 23 and 28 years (%)	Over 28 years (%)
All players combined ($n = 191$)			
Percentage	20.4	45.8	33.8
First choice	16.2	48.7	35.1
Wing players ($n = 52$)			
Percentage	26.1	64.7	9.2
First choice	21.9	65.3	12.8
Pivots ($n = 33$)			
Percentage	17.8	45.9	36.3
First choice	19.6	20.6	59.8
Backcourt players ($n = 80$)			
Percentage	22.2	41.7	36.1
First choice	16.4	55.7	27.9
Goalkeepers ($n = 26$)			
Percentage	12.2	35.8	52.0
First choice	0.0	11.2	88.8

PV (8.3 ± 4.0, $p \leq 0.05$, ES = 1.35) performed more fast breaks than BP (3.4 ± 3.2).

Conversely, BP performed more shots per match (10.5 ± 3.4) than PV (7.0 ± 2.0, $p \leq 0.05$, ES = 1.25) and WP (5.8 ± 2.5, $p < 0.005$, ES = 1.58) and had similar scoring percentage (42.0 ± 14.6%) as PV (48.8 ± 24.2%) and WP (46.9 ± 23.9%). Analysis of the different types of shots was only conducted in BP because both WP and PV primarily finished with jump shots (Figure 1A). Backcourt players performed more jump shots than any other type of shots ($p < 0.001$). Reduced scoring percentage was demonstrated ($p \leq 0.05$) using underhand shots (21.4%), whereas a tendency ($p = 0.09$) for higher scoring percentage by penalties (63.4%) was observed compared with all other types of shots.

Because the mean scoring percentage did not differ between playing positions, the analyses of shots were performed for all players combined (Figure 1B, left panel). Unrestricted shots showed a higher scoring percentage (57.0 ± 22.8%) compared with shots, where players received a hard tackle (33.4 ± 24.6%) ($p \leq 0.05$, ES = 0.98). In contrast, no difference to shots taken while receiving light tackles (45.1 ± 30.2%) was demonstrated. In addition, no difference in scoring percentage depending on on-court position (where the takeoff is carried out) was shown, although there was a tendency ($p = 0.07$) of a higher scoring percentage in shots from the 6-m line (53.5 ± 26.9%) compared with shots from farther away from the goal (~41%, cf. Figure 1B, right panel). The latter analysis was only conducted in BP because only these players were shooting from all 3 court positions analyzed.

In defense (Table 1), WP performed less tackles in total per match (19.5 ± 8.9) than PV (40.3 ± 15.3, $p < 0.01$, ES = 1.66) and BP (31.2 ± 12.2, $p \leq 0.05$, ES = 1.10). In addition, WP received less screenings (0.9 ± 1.5) than both PV (12.4 ± 7.4, $p < 0.001$, ES = 2.15) and BP (6.3 ± 5.7, $p < 0.001$, ES = 1.30) along with less blockings (0.2 ± 0.4) and claspings (1.3 ± 1.1) than PV (5.5 ± 3.2, $p < 0.001$, ES = 2.32; 8.2 ± 5.0, $p < 0.001$, ES = 1.94) and BP (4.9 ± 2.8, $p < 0.001$, ES = 2.35; 3.5 ± 2.0, $p < 0.01$, ES = 1.42).

Differences Between First and Second Half of the Match

The number of major technical playing actions was in most cases found to drop in the second half compared with the first half, irrespectively of the playing position (Figure 2). Notably also, in defense, fewer hard and light tackles were observed in the second half ($p \leq 0.05$) for all players combined.

On average, each player performed 36.9 ± 13.1 high-intense technical playing actions per match. During offense, high-intense playing actions consisted of offensive breakthroughs, fast breaks, hard tackles, and shots, whereas in defense, high-intense playing actions consisted of hard tackles, claspings, and blockings. The mean number of high-intense technical playing actions did not differ from first to the second half (19.2 vs. 17.7). However, in offense, there was a tendency ($p = 0.10$) toward more high-intense technical playing actions in total in the second half. Wing players performed more fast breaks in the second half ($p \leq 0.05$), probably because the opponent defense players were

gradually fatigued, whereas conversely the amount of high-intensity running in defense was lower for WP in the second vs. first half (8). In offense, PV received less hard and light tackles, performed less fast breaks, and committed more technical errors in the second half compared with the first ($p \leq 0.05$). In defense, middle defenders (PV) delivered fewer hard and light tackles ($p \leq 0.05$).

Anthropometric Characteristics of Male Elite Team Handball Players

The mean BH and BM for the players in the 2 top ranked clubs were 188.9 ± 5.3 cm and 90.9 ± 9.0 kg, whereas the mean age and adult elite playing experience were 26.2 ± 3.1 years and 7.1 ± 3.7 years. Wing players showed lover mean BM (80.9 ± 5.5 kg, $p < 0.001$) and less playing experience (5.9 ± 2.4 years, $p \leq 0.05$) compared with all other playing positions. Furthermore, PV were taller (194.7 ± 2.1 cm, $p \leq 0.05$) and heavier (101.4 ± 8.3 kg, $p \leq 0.05$) than all other playing positions (Table 2).

For all players in the Danish Premier Male Team Handball League during 2 selected seasons in total ($n = 348$), the mean BH and BM were 189.6 ± 5.8 cm and 91.7 ± 7.5 kg, whereas mean age and playing experience were 26.1 ± 3.9 years and 7.3 ± 4.5 years. Positional differences were observed, however, where WP in both seasons were lighter, smaller, younger, and less experienced on adult elite level than the rest of the players including goalkeepers. In contrast, PV were heavier and taller than the rest of the field players (Tables 2 and 3).

The potential effect of body anthropometry, age, and playing experience on individual playing time and hence on playing performance can be illustrated by comparing first (players, who were selected for the team's starting line-up) and second-choice players. Because no differences could be demonstrated for all players combined between the first ($n = 157$) and the fourth season ($n = 191$), the comparison is presented only with the latter players (Table 3). In the Danish Premier Male Team Handball League, no differences in mean BH and BM between the 2 choices of players were observed for all players combined, whereas first-choice players were older and more experienced than second-choice players ($p < 0.001$). The same applied for all playing positions except for PV (Table 3). A similar pattern was demonstrated between Danish and foreign players in both seasons, where foreign players were older and had more playing experience than Danish players (Table 3).

The majority of players (fifth season) were between 23 and 28 years old (45.8%) (Table 4). In addition, this age group comprised the highest percentage of players, who were selected first choice (48.7%). For the different playing positions, WP had the highest percentage of players younger than 23 years (26.1%) and the lowest proportion of players elder than 28 years (9.2%).

As the only playing position, WP also demonstrated a higher percentage of first-choice players in players younger than 23 years (21.9%) compared with players older than 28 years (12.8%). Conversely, goalkeepers showed the greatest proportion of players older than 28 years (52.0%) and the lowest percentage of players younger than 23 years (12.2%), and none of the latter players were selected first choice. No systematic relationship was observed between team rankings in the Danish Premier Male Team Handball League (fifth season) and BH, BM, and age, respectively.

Discussion

To the best of our knowledge, this is the first study to examine the physical demands in modern male elite TH using a complete technical match analysis. As main findings, marked positional differences in physical demands and body anthropometry were demonstrated, whereas indications of technical fatigue were observed. The present data showed that elite TH players are highly active and perform a large number of intense physical confrontations (tackles, screenings, claspings, and blockings) with opponent players, hence suggesting a need for high levels of muscle strength, explosive muscle actions (high rate of force development [RFD], cf. 21) and mobility. Because of their short duration, high intensity, and repetitive nature, a number of these technical playing actions are likely to place high demands on both the anaerobic and aerobic energy production.

The present players each performed an average of 8.5 shots per match, which is about the same number reported more than 25 years ago (5,17) and unexpectedly low because new rules, such as the quick throw-off, have increased the number of attacks (16) and therefore led to a greater opportunity for more shots. Backcourt players demonstrated a higher number of shots per match (primarily jump shots) than PV and WP with a similar scoring percentage as all other playing positions.

Although court position of take-off for the shot did not appear to influence scoring percentage, there was a tendency ($p = 0.07$) for elevated scoring percentage for shots taken at the 6-m line compared with shots at a greater distance from the goal. Scoring percentage was found to drop significantly in players who received a hard tackle. It seems to be highly crucial, therefore, that defense players sustain hard tackles throughout the entire match to successfully stress attacking opponents. Offensive breakthroughs were only registered, if they were successful. Obviously, a much higher number of offensive breakthroughs were attempted though not successfully according to the outcome criterion, which explains the relative small number of breakthroughs registered per match for all players combined (1.5).

Wing players had significantly fewer physical confrontations with opponent players than BP and in particular PV, in accordance with previous findings in male elite TH players (20). Pivots performed a higher amount of high-intensity running compared with BP mainly because of a high number of fast breaks. However, PV remained more stationary in the organized attack (attack build-up) because of their relatively fixed position at the 6-m line.

Like in offense, WP showed markedly less body contact with opponent players than BP and PV players in particular. The latter players demonstrated a large number of physical confrontations because of their position in the middle defense, in accordance with previous results in male elite TH players (20). Unlike in offense, the amount of high-intensity running was similar in BP and PV, but in turn much less than seen in WP (9).

Together with previously reported locomotion match analysis, physiological measurements, and physical test outcomes (8,9), the present data indicate that male elite TH places a relatively high aerobic workload on players, whereas the rate of anaerobic energy turnover in short periods of time is very high. The latter notion is supported by findings that the present players on average had 37 high-intense technical playing actions of ~3 seconds duration and showed moderate-to-high post-match blood lactate concentrations (range: 3–11 $mmol \cdot l^{-1}$) (8). Players were observed to work intensely in short, intermittent periods that alternated with periods of standing still, walking, running, sprinting, moving forward and backward, and side-stepping. In addition, players frequently were tackled, grappled, and pushed.

Based on the number of high-intense technical playing actions, anaerobic demands likely were higher in players, who covered WP positions in offense while covering BP positions in defense than players, who conversely played BP positions in offense and covered WP positions in defense (cf. Table 1). This suggests that the teams' tactical approach influences the technical and physical performance in elite TH. Thus, different offensive and defensive systems as well as various playing position-specific tasks performed during match-play seem to have an impact on the physical demands imposed on the players.

In support of this notion, substantial inter- and intra-player variability in the amount of technical playing actions was observed between different games and even within specific playing positions in this study, possibly in part due to variable situational factors such as match location (home vs. away), quality of opposition (top, medium, and bottom) and match status (winning, drawing, or losing). However, because of the large number of matches and players analyzed in the present study (62 matches of different tactical/strategic importance, involving 82 analyzed players from several different teams recorded during 6 competitive seasons) our findings may suggest a realistic picture of the nature and amounts of technical playing actions in male elite TH players during actual match-play.

In this study, we examined the specific physical demands of male elite TH by performing a time distribution analysis of the technical playing actions (tackles, breakthroughs, fast breaks, shots, technical errors, and defense errors) and concurrent intensity levels. In support of previous conclusions based on locomotion match analysis in the same players (and matches) (9), the present study provided direct evidence that positional differences in the physical demands may exist in male elite TH match-play. Consequently, the average amount of technical playing actions for all players combined will depend on the specific number of players analyzed in the various playing positions.

Wing players are characterized by a high-intensity locomotor pattern as reflected by a high number of fast breaks and an ability to cover a relatively large total distance (9). However, the low number of high-intense playing actions in these players in the present analysis suggests great muscle strength during tackles and in-fights to be of less importance in this playing position (cf. Table 1). Conversely, PV were characterized by a high number of physical contacts with opponent players and large amounts of high-intensity fast break running (Table 1), suggesting that in high-intense playing actions, high levels of muscle strength and RFD are strongly desirable in this playing position. The low total distance covered (9) suggests aerobic intermittent endurance exercise capacity to be of lesser importance for PV players, although the need to recover after repeated high-intense playing actions likely means that a critical level of aerobic capacity is required as well.

In this study, BP demonstrated a relatively large number of physical confrontations and shots (Table 1) suggesting a need for great muscle strength and RFD along with adequate aerobic intermittent endurance exercise capacity to accommodate the large total distance covered per match (9). In contrast, anaerobic running capacity seems to be of lesser importance in BP, as suggested by the low number of fast breaks and also by previous observations of low amounts of high-intensity running in this playing position (9).

In accordance with the results from the locomotion match analysis (9), the amount of technical playing actions decreased from the first to the second half indicating that technical fatigue and impaired physical performance may occur in male elite TH, at least in some players. This explains, at least in part, the observation of a reduced relative workload (% of $\dot{V}O_2$-max) in the second half (8). It should be recognized, however, that this study did not examine specific fatigue factors. Such aspects have been more thoroughly addressed in separate investigations from our laboratory (21,24).

The declines in the analyzed parameters in the second half were influenced by situational variables such as match location, opponent level, and match status. However, the present data still represent a valid overall estimate of the technical match profile of elite male TH players and thus of the match-induced impairments in physical performance in the second half because of the large number of matches and players analyzed in this study (62 matches of different tactical/strategic importance, involving 82 analyzed players from several different teams recorded during 6 competitive seasons).

The mean BH in the Danish Premier Male Team Handball League was similar to that of international top-level elite players (190 cm vs. 189 cm and 187 cm) (1,2), but BM appeared to be lower compared with the players from the

same studies (92 kg vs. 95 kg and 95 kg), suggesting that BM and hence probably also muscle mass and strength may have an important influence on playing performance in international top-level male elite TH. This was supported by previous data, where international top-level male elite players had similar BH, but higher BM, lean BM, and BM index, and performed better in different strength test than amateur players (2).

Studies of male players from the Danish National Team and 2 Danish National Youth Teams (U-20 and U-18 Teams, respectively) revealed that adult national team players had similar BH, but were heavier with a higher lean BM (and hence probably more muscle mass) than youth national team players, while being just as fast and explosive with the same maximal oxygen uptake ($\dot{V}O_2$-max) and endurance capacity as observed in the younger and lighter players (3). This indicates that heavy and strong players (adult national team players), who are not compromised in regard to running capacity or speed, will have a clear advantage compared with lighter players (youth national teams players) because they are expected to be superior in physical confrontations during elite TH match-play.

In a study that compared athletes from different sports, TH players were taller and heavier than soccer players in a sample of Kuwaiti national team players (15). The present players in the Danish Premier Male Team Handball League were substantially taller and heavier than both elite players from the Danish Premier Male Soccer League and international top-elite male soccer players (13), which suggests that distinct physical differences exist between the 2 types of ball games.

In Denmark, players from the male National Team have been tested continuously since the mid 70s (4). Notably, over the past decades, the players seem to have become progressively taller and heavier with increased muscle mass, from the BH and BM of 185 cm and 82 kg reported in 1976 (12) to reach BH and BM values of 192 cm and 94 kg, respectively, in present-day national team players. In the present study, no differences in body anthropometry could be observed between Danish male national team players (separate data not reported) and the players presently examined from the Danish Premier Male Team Handball League.

The present results confirm the gradual development of today's tall and heavy male elite TH players with large muscle mass. Large BH and high BM represent a clear advantage in specific game situations such as when shots are performed from a long distance from the goal as showed by Wagner et al. (22) who demonstrated that tall TH players with large BM have the ability to achieve a higher ball release speed in the jump shot than smaller players. The latter is the most common type of shot used by BP, who preferentially shoot from a long distance as both observed in this study and reported by Wagner et al. (23). In line with these observations, the absolute $\dot{V}O_2$-max ($l\ o_2 \cdot min^{-1}$) also has improved in male elite TH players concurrent with the increase in BM and muscle mass (8).

Based on these data, it seems desirable to develop players who are heavy and strong in breakthroughs and hard to block defensively while during an entire game are able to perform fast running and side-stepping actions combined with a great mobility both in offense and defense. However, in the present group of players, no relationship was found between team rankings in the Danish Premier Male Team Handball League (fifth season) and mean BH and BM, respectively. Thus, factors other than body anthropometry also seem to have an impact on the success in elite TH match-play. In addition, no differences in mean BH or BM were observed between first- and second-choice players.

A number of positional differences in body anthropometry were demonstrated, but also individual variations were observed within each playing position. In both seasons, WP were lighter and smaller than all other players (including goalkeepers), which from a physical point of view was in accordance with the physical demands imposed on this playing position. Great muscle strength/RFD thus seems to be of lesser importance for WP as discussed above. Furthermore, WP does not normally need to jump and shoot over the blockings of the defense. The less heavy and smaller size of WP enable these players to repeatedly perform rapid high-intensity movement patterns over short distances, while covering a large total distance of running per match.

Pivots were the heaviest and tallest of all playing positions with a mean BM of 99.4 kg (fifth season), concurring with results obtained in elite Croatian TH players (18). This likely reflects a high consistency between players' body anthropometry and the physical requirements of modern PV match-play. Thus, large BM (and hence muscle mass) likely has substantial importance for successful PV playing performance because of the high frequency of in-fights with opponent players, in turn indicating high levels of muscle strength and RFD to be essential performance elements in this playing position. The importance of a high BM was underlined by the substantial difference in BM of PV selected first choice vs. second choice in the first season. The high BH in the middle defense for PV players also seemed to be important for playing performance e.g., to produce effective blockings.

In the present group of male elite TH players BH and BM differed significantly in the order WP $<$ BP $<$ PV, again suggesting a systematic relationship between body anthropometry and position-specific physical requirements. In support of this notion, BP have a need for high BM (i.e., large muscle mass) to provide sufficient muscle strength/RFD during the relatively large number of physical confrontations and the many shots taken at this playing position. In addition, BP also need to be relatively tall to shoot over defense blockings from a large distance. Conversely, BP were lighter than PV probably because of the relatively high aerobic demand and huge mobility range reflected by the high total distance covered (9) and likely in consequence of their central position in the offense, which involves large amounts of motion with many lateral (sideways) movements. Overall, the present

findings are in close accordance with previous results from Srhoj et al. (19) who concluded that it would be sensible in elite TH to select players, whose morphological profiles are most compatible with positional specificities in the demands of the game.

Wing players were younger and had less playing experience than all other players. Because of less involvement in organized play and a reduced need for great muscle strength caused by fewer physical confrontations, inexperienced players are more frequently allocated to this playing position. For all players combined and for all playing positions (except PV), first-choice players were consistently older and more experienced than second-choice players. In addition, goalkeepers were significantly older than the rest of the players, indicating that goalkeepers compared with field players are better able to sustain a high performance level at higher age. This may be due to a relatively higher importance of progressively accumulated experience at this position into various tactical aspects of the game (shot statistics, anticipation techniques, etc.), which for goalkeepers to a greater extent can compensate for the decline in physical shape.

For all players combined (fifth season), the majority of players were aged between 23 and 28 years. Notably, this age interval contained the highest percentage of players selected first choice at their respective playing positions, indicating that the age range of 23–28 years represents an optimal combination of significant game experience and sufficient physical capacity. However, team rankings in the Danish Premier Male Team Handball League (fifth season) were not related to mean player age. Consequently, factors other than mean player age seem to influence the success of top-level TH teams.

Conclusions

As demonstrated by the present data, modern male elite TH is a physically demanding and complex game characterized by a high number and a great variety of short-term, high-intense technical playing actions that are performed intermittently throughout the entire match. The observed decline in the amount of technical playing actions during the second half period indicates that technical fatigue and impaired physical performance may occur at least in some players. Substantial positional differences in the physical demands were observed. In addition, body anthropometry seems to play a crucial role for playing performance at the various playing positions.

Practical Applications

The traditional approach in elite team handball of conducting identical physical training for all players on a given team is challenged by the present observations of substantial positional differences in the physical demands during elite team handball match-play. Thus, the present findings suggest that more individualized training regimens should be developed to maximize the position-specific physical development in male elite team handball players. Consequently, specific physical training should be designed to more selectively target the various playing positions, hence ensuring optimal development of the physical capacity of individual players.

Based on the present data and previous analysis (9), high demands seem to exist for a superior acceleration and deceleration capacity, high RFD, great ability to perform fast and hard shots, rapid side-cutting maneuvers, and a high number of strength-demanding physical confrontations (e.g., pushing and holding). Thus, an intensified focus on anaerobic training aspects and on resistance training seems highly relevant for male elite team handball players. The latter training should comprise both basic strength training and explosive-type RFD-training to make the players capable of performing the above playing actions at sustained high levels throughout the entire match.

Significant anthropometric development seems to have occurred in male elite team handball, where today's players were found to be markedly taller and heavier than 25 years ago. Concurrently with this development in body anthropometry, modern male elite team handball players need to maintain or even improve functional characteristics such as acceleration capacity, ability to perform rapid changes of direction, and show high maximum jump height and movement agility, while attaining adequate intermittent endurance running capacity on the playing court despite their larger and heavier bodies. Consequently, specific physical training modalities should be employed to target these performance components to optimize the functional capacity in modern male elite team handball including e.g., on-court jumping, sprinting, and strength/RFD exercises performed with balls in game-like situations.

In addition, future studies should be performed to examine the impact of different training regimens (strength vs. anaerobic vs. aerobic exercise) for increasing the physical fitness in elite team handball players and to provide improved fatigue resistance during elite team handball match-play. The present findings and conclusions were obtained by examining male elite team handball players, who were on the playing court for the majority of total match duration (70% or more), and hence served no specialist roles (i.e., playing only offense or defense). Consequently, future studies should examine the physical demands of players with greatly reduced on-court playing time (i.e., specialized or substituted players) to evaluate the activity patterns of such players and to provide valuable information about the specific rotation/substitution strategies used in male elite team handball match-play.

Finally, the physical demands imposed on national team players during international tournaments with multiple matches in a compressed period should be subject of further research because the physical loads for elite team handball players under these conditions are likely to differ from the regular tournament match season that has longer recovery time (typically 1 week) between successive matches as in this study.

Gaining an increased knowledge about the physical demands imposed on male elite team handball players is

important for evidence-based recommendations for the future planning and execution of physical training. Overall, the present observations suggest that male elite team handball players should perform specific physical training in relation to their playing position(s) and individual capacity and additionally focus especially on intense strength training and anaerobic training to enhance their functional physical performance on the team handball court (7).

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