INSTITUTIONEN FÖR KOST-
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Force-velocity profiling among handball-players

Differences between

player-positions

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Bachelor thesis 15 hp

Program: Sports Coaching

Vt 2020

Supervisor: Dan Fransson

Examinator: Stefan Lindinger

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Summary (Eng)

Modern handball has an intermittent character which includes several complex physical qualities. Knowledge of these individual physical demands between player positions seems to be essential in order to design optimal training programs to maximize players potential on the pitch. *Purpose:* investigate if the vertical force-velocity profile is related to player position in elite male team handball and evaluate if there is a significant difference in how players expresses their mechanical power output when comparing pivots and wings. *Method:* Thirty elite handball players (Wings N=17, Pivots N=13) from Swedish top division handbollsligan performed total eight vertical squat jumps (SJ) with loads ranging from 0-60 % of their bodyweight. Jump height (cm), velocity (m/s), relative force (N/kg), absolute force (N), % imbalance (%imb) and power- max (Pmax) (w/kg) were recorded and analyzed with a scientifically validated iPhone app (MyJump). *Results:* Jump height is significantly (37.90 cm vs 44.05 cm, SE=2.059, p=0.006) greater among wings but in contrast pivots significantly express more absolute force (3162.15 N vs 2741.17 N, SE=147.93, p=0.008). Wings have higher velocity (2.85 m/s vs 3.19 m/s, SE=0.168, p=0.048) and there is a significant difference between the groups in their Pmax. (22.58 w/kg vs 26.20 w/kg, SE=1.095, p=0.003) *Conclusion:* It exist a difference between pivot and wings when we compare relative force, absolute force, velocity, Pmax and Jump height. Notable is that wings when performing an unloaded and loaded squat jump are better suited to handle their relative strength (N/kg) compared to pivots who express a higher absolute force (N).

Sammanfattning (Swe)

Modern handboll har en intermittent karaktär som inkluderar ett flertal komplexa fysiska kvalitéer. Kunskap om dessa individuella fysiska krav mellan positioner verkar vara essentiella för att designa optimala tränings program för att maximera spelarnas potential på plan. *Syfte:* undersöka om vertikal kraft-hastighets profilering är relaterat till spelar-position inom manlig elit-handboll och utvärdera om det finns signifikant skillnad mellan hur spelarna uttrycker sin mekaniska effekt—produktion vid jämförelse mellan positionen mitt-sexa eller kantspelare. *Metod:* Trettio manliga elit-handbollsspelare (Kant N=17, mitt-sexa N=13) från Svenska Handbollsligan utförde åtta vertikala knäböjshopp (SJ) med olika belastningar 0–60% av egen kroppsvikt. Hopp-höjd (cm), hastighet (m/s), relativ kraft (N/kg), absolut kraft (N), % obalans (%imb) och maximal effekt utveckling (Pmax)(w/kg) samlades in och analyserades med en vetenskapligt validerad iPhone applikation (MyJump). *Resultat:* Hopp-höjden var signifikant (37,90 cm vs 44,05 cm, SE=2,059, p=0,006) större bland kantspelarna men mitt-sexor hade i motsats mer absolut kraft uttryckt (3162.15 N vs 2741.17 N, SE=147.93, p=0,008). Kantspelare hade högre hastighet (2,85 m/s vs 3.19 m/s, SE=0,168, p=0,048) och det är en signifikant skillnad mellan grupperna i deras Pmax. (22.58 w/kg vs 26.20 w/kg, SE=1,095, p=0,003). *Konklusion:* Det existerar en skillnad mellan mitt-sexor och kantspelare när vi jämför relativ kraft, absolut kraft, hastighet, Pmax och hopp-höjd. Mest noterbart är att kantspelarna kunde hantera deras relativa styrka (N/kg) bättre till skillnad mot mitt-sexor vid hopp med kroppsvikt och hopp med extern belastning. Däremot uttryckte mitt-sexor bättre absolut kraft (N).

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Keywords

Force-Velocity Profiling, Force-Velocity Relationship, Handball, Performance Analysis, Activity profiles, Vertical Jump, Developing Power.

Abbreviations

FVC Force-Velocity Curve
FVP Force-Velocity Profiling
FVR Force-velocity Relationship
SJ Squat jumps
CMJ Countermovement jump
Pmax Maximal power output
V0 Maximum velocity in meter/sec
F0 Maximum relative force in N/kg
N Newton
%imb Percentage imbalance between force and velocity which creates an individual Pmax
Sfv Linear slope in force-velocity relationship
Sfopt The assumed optimal balance between force and velocity for an individual

PAP Post activation-potention effect: A heavy muscle activation influences the subsequent muscle contractions. Engagement of the nervous system produces an increase in contractile functions and possible following performances.

Authors contributions

Work assignment	Procentage by Pontus/Kalle
Planing of study	50/50
Search of litterature	50/50
Data collection	50/50
Analyzing	50/50
Writing	50/50
Layout	50/50

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Introduction

Handball is a professional and Olympic sport with roots all the way back to the 1800-century and is today widespread all over the world. The formation of the game has evolved over the years from being played on a football pitch and eleven versus eleven participants until today's modernization. In the modern intermittent handball seven players compete for each team (one goalkeeper and six outfield players) and the game is played on a 40 x 20-meter court. Games are divided into two periods of 30 min each with a 15 min half-time break. The teams can make as many substitutions they want during the game which is a crucial factor to avoid excessive fatigue and maintain freshness. The ability to intermittently perform maximal short-duration activities during games is crucial to obtain a high level of performance.

The sport is characterized by a lot of different physical ballistic actions like jumping, sprinting, throwing, change of direction, accelerations, decelerations, high intensity actions and collisions between players (Lutberget & Spencer, 2017; Michalsik, Aagaard & Madsen, 2013). In addition to that is also includes a lot of technical and tactical skills. Taken all this together it could be reasonable to think that modern handball is a complex sport which require a wide range of physical and sport specific skills. There seems to be a wide variation in anthropometrics and physical demands between positions and therefore needs be explored through a more deeply analysis. In fact, previous studies found differences between playing positions regarding the total distance covered and distance covered at different locomotor categories during game time (Cardinale, Whiteley, Hoshny & Popovic, 2017; Michalsik, Agaard & Madsen, 2011; Karcher & Buchheit, 2014; Büchel, Jakobsmeyer, Döring, Adams, Rückert & Baumeister, 2019; Ghobadi, Rajabi, Farzad, Bayati & Jeffreys, 2013). This information about on-court demands during match-play might enable individualisation of training loads to develop and maintain performance throughout the season according to what actually happens during the game. If there is a difference in locomotor patterns and activity profiles during a game, it would be hypothesized that team handball players will show position-related differences in physical abilities expressed through a ballistic force-velocity profiles. This variation is something that needs to be assessed and could possibly provide strength and conditioning coaches with tools to design more optimal individualized programs.

Ballistic activities may be a key factor in team handball because of the locomotor characteristics (Michalsik et al., 2013; Cardinale et al., 2017) and can be defined as the ability to accelerate a mass as much as possible in the shortest time available (Contreras-Diaz, Jerez-Mayorga, Delgado-floody & Arias-Poblete, 2018). It could be body mass in sprint and jumping or with an external mass like in throwing (Samozino, Sangnier, Edouard & Brughelli, 2013). It is possible that the ability to perform physically in team handball could therefore be strongly related to a high maximal power output (Pmax) the limbs can develop. Power output is the product of force and velocity and a optimal balance between them could in this case result that the player express a greater Pmax (Jiménez-Reyes, Samozino, Brughelli & Morin, 2016; Cuk, Markovic, Nedeljkovic, Ugarkovic, Kukolj & Jaric, 2014). In turn, ballistic performance like jump height is largely determined by an individual Pmax (Samozino, Rejc, Pramperio, Belli & Morin, 2012). Which could possibly lead to performance enhancement if the player increases his jump height (cm) during ballistic actions like vertical jumping (Morin & Samozino, 2016). That means, if a player improves his jump height, it would eventually give the player more flight time and yet in turn more options when passing or finishing (Michalsik, et al., 2013; Póvoas, Ascensao, Magalhaes, Seabra, Krustrup, Soares & Rebelo, 2014). In addition to that has the jump height shown to be connected to better sprint and acceleration performance among athletes. (Cronin & Sleivert, 2005; Sáez de villareal, Requena & Cronin, 2012) Which is possibly a fundamental ballistic ability in team handball. (Büchel et al., 2019)

1.2 Purpose

Nevertheless, no studies so far have investigated in detail if the force-velocity profile is related to player position in elite male team handball. The purpose of this bachelor thesis is to investigate if there is a difference in force-velocity profile during vertical jumping (Squat jumps) between player position (wings and pivots) in team handball.

Background

2.1 Position demands in handball

Knowledge of the typical position-specific demands between pivots and wings is essential for the design of the individualized program and drills. A coach needs to be aware of the unique locomotor patterns and activity profiles during a game. Wings tactical role is different because they play mostly of their game time on the outer part of the pitch and are involved in more rapid counter attacks.

The whole game has an intermittent character and a significant difference in locomotor activities between positions with wings cover the most total distance (average 3339.2-3403m) compared to pivots (average 2419m). Wings also covered the largest distance at high speed and sprinting (average 1226-1134m) and also reach the highest top speed throughout the game (Cardinale et al., 2017) In addition pivots are positioned in the center of the pitch and generally run less than all outfield players but with an increased number of body contacts and collisions (Michalsik et al., 2011, 2013). They also performed more lateral displacements compared to wings who expressed more horizontal (Kercher & Buchheit, 2014). It would therefore be possible to think that wings are faster (velocity) but pivots are stronger (force) to handle the increased number of situations and collisions with opponents (Büchel et al., 2019).

This could explain the large difference in activity-profiles where pivots average is bigger to resist the number of body contacts in the center of the pitch and wings average is smaller and quicker to accelerate faster in counter attacks before the opponents have return to defense-mode (Michalsik et al., 2011, 2013). In addition, Ghobadi et al. (2013) reports huge differences in body anthropometrics with pivots (average 192cm/99.66kg) being taller and heavier compared to wings (average 185cm/84.66kg) during the world championships 2013. This trend in match-profiles and anthropometrics is also visible in more research throughout the area (Kercher & Buchheit, 2014; Büchel et al., 2019; Michalsik et al., 2011, 2013).

2.2 Force-Velocity relationship (FVR)

The relationship between force (N/kg) and velocity (m/s) is described by using the force velocity curve (FVC). The FVC is a converse relationship between if the concentric muscle forces are high, there be less velocity generated. The same relationship occurs where velocity is high, then the concentric muscle force is low. However, in eccentric muscle-actions the relationship is high force = high velocity and low velocity = low force (Cormie, McGuigan & Newton, 2011a). The variables that need to be considered in human movement to perform as much power as possible is muscle-fiber type, architectural characteristics and anatomical structure (Cormie et al., 2011a). The relationship will be determined by what muscle or muscle-groups that are activated because of the actin-myosin cross-bridges. The cross-bridges is an indicator for how much power is produced, for it takes a certain amount of time for cross-bridges to attach to each other during power development, and it also takes a certain given time to detach. It is the number of cross-bridges attached that will determine how much power will be produced during for example a vertical jump. If the test person has a high velocity during a vertical jump it means that the cross-bridges time to attach will decrease and that will lead to less force produced. Then the curve will show the results by how much we lack in either force or velocity for an optimal power production (Cormie et al., 2011a) (Suchomel, Comfort & Lake, 2017)

2.3 What is force-velocity profiling?

The individual force-velocity profile (FVP) is determined by the individual balance (%imb) between Vmax (V0) and Fmax (F0) (Morin & Samozino, 2016) in FVC which is an explanation of how they produce their Pmax. This simply method was first described by (Samozino, Morin, Hintzy & Belli, 2008).

The fundamental part of a vertical jump is the ability to develop high impulse against the ground (Maximal force production, N/kg) and reach maximal velocity (m/s) in the end of a push-off when the lower limbs reach full extension. (Morin et al., 2016). The dependent values of FVP is the Fmax (F0), Vmax (V0), Pmax (w/kg) and the maximal jump height (cm) which creates a linear slope (Sfv) and the assumed optimal balance (%imb) between force and velocity for an individual (Sfopt).

An individual's ability to jump high seems to be highly determined by power output (Pmax) in lower extremities and the individual´s combination of the underlying mechanical outputs (F, V & Pmax) (Jiménez-Reyes et al., 2014; Jiménez-Reyes, Samozino, Brughelli & Morin, 2016). According to Morin et al. (2016) there is a proposed recommendation that the individual %imb should be below 10% to consider the player as optimal balanced and maximize their potential to jump high.

Method

3.1 Design

This study was a quantitative study with a descriptive study design. We aimed to investigate a specific population (male elite handball players) and the individual force-velocity characteristics between player positions pivots and wings.

3.2 Collection of literature

The collection of literature was done by searching through a various of electronic databases. We choose to search data from EBSCO, SPORTDiscus, Scopus and PubMed. These databases were chosen in line with the study's aim. In these databases we used search-words in order to collect relevant literature. We also used last names of different researcher in the field to find relevant literature.

In the identification process we came across n=2936 in which we chose to exclude n=2884 due to title or abstract. Screening-process of this literature left us with 52 articles that were picked out for reading. Additionally, n=29 articles were excluded after reading study design, aim, result or discussion. When searching in these databases we used search-words based on "Force Velocity Profiling AND, Vertical Jump, Activity profiles handball, Handball performance analysis, Vertical jump, Developing power, Myjump app. We also search after various of known researches in this field, Balsalobre, Jimenez Reyes, JB Morin, Samozino for example. See flowchart *figure 1* to find exact search-words.

In the end we selected n=31 articles in which n=8 articles were picked from reference-lists in other articles. These selected articles were picked because of their information that was a fit to our aim of the study. A wider description in the collection of literature in flowchart below (figure 1).

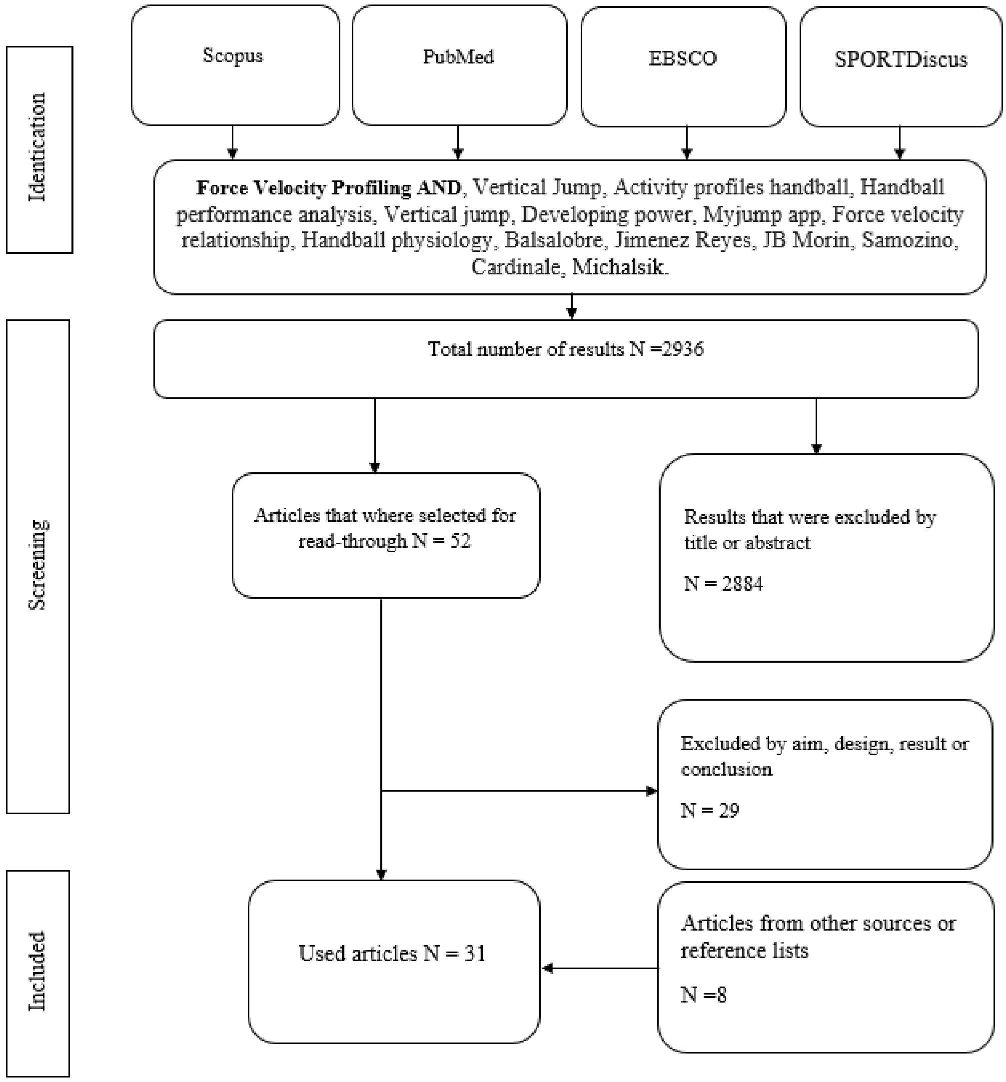

Figure 1.

3.3 Subjects

The invitation and information about the study were sent out to all the male teams in the Swedish top division handbollsligan. The subjects had to be healthy and no injuries at the moment or the six latest weeks. They were also required to have one of the positions pivot or wings, at least one-year experience of strength training, contracted as a part of the elite club and would at least be born 2002. The participants were required to only have a low intensity and low volume session the day before or no scheduled game the day after. At total five different teams and thirty-one professional male players (Pivot=13, mean age=23.6 body mass=99.46kg, height=192.6cm) (Wings=17, mean age=22.5, body mass=83.5kg, height=184.8cm) agreed to participate in the study. All subjects were informed of the benefits and the risks of the research verbally and through a document and were asked to confirm it by a written consent.

They were also informed that they could cancel at any time with respect to the principle of autonomy. This study's methodological consideration was designed after declaration of Helsinki (1964) and especially the four ethical principles (Kristensson, 2014, p. 52-53). All participants were informed that the data were strictly confidential and handled with respect of the individual integrity. The testing procedure were carefully adapted to minimize the risk of injury and participants overall health. If they had any minor feeling of discomfort or pain the test procedure was immediately canceled.

Table 1. Descriptive statistics for the subjects are presented in table 1 and divided into their positions. All values are presented as mean and distributed over pivot and wings.

Descriptive Statistics

Table 1

Position	N	Age (yr)	Weight (kg)	Height (cm)
Pivot	**13**	**23.6±4.1**	**99.4±7.1**	**192.6±5.1**
Wing	**17**	**22.5±4.6**	**83.5±7.2**	**184.8±4.8**
Total	**30**	**23±4.3**	**90.4±10.6**	**188.2±6.2**

Descriptive statistics for participants distributed over pivots and wings.

3.4 Background testing

Anthropometric measurements (weight) via a body-scale. (Polar, Kempele, Finland) The height was measured with an aluminum stadiometer (Seca 713 model; Seca, Postfach, Germany). A tape measure was used to determine the individual push off distance from the length of the lower limbs as recently described by Samozino et al. (2008, 2012, 2013). It was measured in two different steps and started first with that the participant laying down on their back, fully extended from iliac crest to ankles and the relation between them were noted (centimeters). The second step included the participant in a squatting position at 90 degrees (knee flexion) and notes were taken from iliac crest to the ground. (centimeters) These values were necessary to correctly determine in order to do a vertical force-velocity profile. (Morin & Samozino, 2016)

3.5 Warm-up procedures

Participants performed a standardized warm up for 10 minutes consisting of 3 minutes cardio (e.g. cycling, running, rowing), dynamic stretching 2x6sec for gluteus maximus, tensor fasciae latae, plantar flexors and mobility in a squatted position. At the end they were instructed to do one set and three reps of maximal CMJ's and one set of three reps back squats with 50% of their bodyweight in order to use to post-activation potention effect (PAP) (Cormie et al., 2011a; 2011b) and to optimize their preparations. There was no specified resting time between sets in warm up protocol. Similar methods for warm up had recently used by other investigations. (Giroux, Rabita, Chollet & Guilhem, 2016; Jiménez-Reyes et al., 2017; Jiménez-Reyes et al., 2014; Jiménez-Reyes., et al 2016; Escobar-Alverez, Fuentes-Garcia, Da-Conceicao & Jimenez-Reyes, 2019) There were one observer at the lateral side of the participant to check the right degree of the knee angles and provide verbal feedback and one in the front who collected the data.

3.6 Jumping testing

To determine the individual Force-velocity relationships, each subject performed minimum one and maximum two repetitions vertical maximal SJ with one-minute rest between on four different loads. The first load included bodyweight SJ (0%) while keeping their hands on their hips and the rest additional against three extra different loads (barbell) ranging from 20, 40 and 60% of their bodyweight with hands on the barbell. (Samozino et al., 2014; Jiménez-Reyes et al., 2014; Giroux et al., 2016; Jiménez-Reyes et al., 2017). Countermovement was verbally forbidden and carefully checked by one of the instructors using an ordinary camera on a iPhone device (iPhone 7; Apple, Cupertino, CA). The push off began when the instructor gave a verbal signal after two seconds at 90-degree knee angle and the rear part touched the elastic cord to ensure consistent push-off distances across loads. (Escobar-Alvaréz et al., 2019)

The participants were instructed to rest one minute between the two attempts on each load and two minutes between each set when the load was increased on the barbell. Only if the participant failed at the first attempt (e.g. not enough knee flexion, loss of balance or if they failed to jump at least ten centimeters) they were given another second attempt. The entire procedure was restarted. They were given two chances on every load and the best performance of these two were noted. (Escobar-Alvaréz et al., 2019). At total they performed minimum four and maximal eight SJ during the whole procedure on four different loads. If they were not able to jump ten centimeters on the 0% of BW jump on the two attempts, as recommended in the literature (Morin et al., 2016) they were excluded from the study. All the SJ were performed with a barbell, weights and lifting platform from Eleiko Inc (Halmstad, Sweden). This protocol is previously recommended by Morin, et al. (2016) in order to avoid excessive fatigue and evaluate FVP.

3.7 Data analysis

The test was performed and analyzed by using a scientifically validated smartphone app (*MyJump 2)* on an iPhone device (iPhone 7; Apple, Cupertino, CA) featuring a camera frame rate of 240 fps. (Balsalobre-Fernandéz et al., 2015; Gallardo-Fuentes et al., 2015)

My Jump automatically calculated the collected data from the test procedure and through the app that were based on the simple method equations from Samozino et al. (2008, 2012; Morin & Samozino, 2016) which includes system mass (body mass plus external loads), jump height and push-off distance. The app provided information regarding the magnitude, direction and the slope of FVP and the imbalance of each player: (FVimb), mean F0, mean V0 and the Pmax. In addition to that it also detected jump height from the total flight time recorded from push off to landing.

The height (cm) from each jump were collected and compared to the individual mean F0 and V0 from the entire push-off distance. (Jiménez-Reyes et al., 2014) The athlete was instructed to maximize their effort in a predetermined number of jumps (eight attempts) and the app automatically calculated the jump height of the total flight time from the pregiven attempt. The person who was in charge recorded the jump in a video and used the slider on a iPhone to navigate through the video and pressed the arrows to move frame-by-frame for better accuracy. The next step was to select take-off from the end of push-off distance which no foot touched the ground. The last step included to select landing in the first frame in which at least one foot touches the ground. The best performance of the two attempts on every load were carefully evaluated and collected for the analysis.

3.8 Statistical analysis

The dependent variables of the study are Relative F (N/kg), Absolute F (N) Velocity (m/s), Power-max (w/kg), SJ jump height (cm) and difference between magnitude of the actual and optimal F-V profile for each individual. (%imb). All values are presented as mean and standard errors (SE). Level of significance is set at an alpha level at p=0.05 for the results.

The level of scale on our variable was ratio-scale because the study aims to compare numerical data between two variables. In this descriptive study design, we analyzed the variables through a student t-test and described it in mean, significance (p=value) and standard errors (SE). SE were selected to analyze the level of significance and is a marker of how precisely our sample is distributed around the mean. It describes the average of all deviations from the mean.

The data were pooled by relative force/kg, velocity, maximal power output, jump height and absolute force. The absolute force was calculated as expressed value of N/kg from *My Jump* times the participants bodyweight with a calculator in a iPhone device (iPhone 7; Apple, Cupertino, CA). All statistical data were performed and analyzed using STATA 16 software (STATcorp LLC Inc., Texas, USA).

Results

Comparisons between positions

Table 2

Variables	Pivot	Wing	Mean Pivot	Mean Wing	dif	SE	p value
Absolute F (N)	13	17	3162.15	2741.17	420.97	147.93	.008
Pmax (W/kg)	13	17	22.58	26.20	-3.619	1.095	.003
F0 (N/kg)	13	17	31.88	32.88	-.995	1.636	.548
V0 (m/s)	13	17	2.85	3.19	-.346	.168	.048
SJ (cm)	13	17	37.90	44.05	-6.145	2.059	.006
Imb (%)	13	17	15.49	20.58	-5.096	5.358	.349

F, force. Pmax, power maximum. W/kg, watt/kilogram (bodyweight). V, velocity (meter per second). SJ, squatjump (centimeter). Imb, imbalance by percentage between force and velocity which creates their individual Pmax.

The distribution and comparisons are presented under table 2. All values are presented as mean and standard errors (SE). Level of significance is set at an alpha level at p=0.05 for the results. All variables were not statistically significant. Jump height (cm) is significantly (p=0.006) greater among wings compared to pivots but in contrast pivots significantly express more total force (p=0.008). In addition, wings have higher velocity than pivots (p=0.048). There is no statistical significantly difference between positions when comparing % imbalance (p=0.349) and relative strength N(kg) (p=0.548). But there is a statistically significant difference between pivot and wings in their Pmax. (p=0.003.

Discussion

5.1 Method discussion

This method by Samozino et al. (2008, 2012) has been used in a wide research throughout the area to evaluate the force-velocity profile. (Giroux et al., 2016; Jiménez-Reyes et al., 2016; Samozino et al., 2014; Morin & Samozino, 2016; Jiménez-Reyes et al., 2013) But recently the scientifically approved iPhone app *My Jump* has been evolved by scientists (Balsalobre et al., 2015) and used in reality by Escobar-Alvarez et al. (2019). The app has also been validated (Gallardo-Fuentes et al.,

2015) with an almost perfect agreement against force plates ($p<0.001$) which confirms that it can give a very accurate result during jumping compared to expensive force plates and jump sensors.

The SJ method has recently been used by a lot of researchers throughout the area in order to evaluate FVP. (Giroux et al., 2016; Jiménez-Reyes et al., 2016; Samozino et al., 2014; Samozino et al., 2013; Jiménez-Reyes, Samozino & Morin, 2019) and despite its expected performance decrement (5-10%) (Jiménez-Reyes et al., 2014) compared to the opposite method CMJ (countermovement jump) this method is highly valid and reliable when the sample is large and the time to physical assessment during elite sport is inadequate. This because of the possible errors that could exist if the athlete turns at undesirable and incorrect angles, we chose to simplify the test procedure (e.g. stop at 90 degrees). Therefore, we decided that the SJ method would be a better choice to our investigation when we analyze a big sample and have limited time available.

By that, we will encourage readers to be aware of this difference in jump height and be careful when comparing investigations in the area with the two methods CMJ and SJ since CMJ have a higher degreement of stretch-shortening cycle. (Cormie, McGuigan & Newton, 2011b) We believe that this is a reason to keep in mind when analyzing the result and be aware of that this is two completely different test methods for FVP.

The type and amounts of loads vary among the literature. Morin & Samozino (2016) recommend at least five different additional kind of loads while García-Ramos et al. (2018) provide evidence that it is enough with two to get a valid result and that has some advantages with reduced fatigue and timesaving. At the same time have two others (Jiménez-Reyes et al. 2014; Contreras-Diaz et al., 2018) proposed that the amount of additional loadings should range between two to seven. But the stakeholders should be aware of that more loads gives an even more accurate result. For example, we think that a strong athlete is still able to accelerate a load on 60% with high quality and the result could therefore had been different if we load him with 80%.

The amount of weight to be increased is governed by the athlete's total experience. Morin et al. (2016) recommends that a novel individual could use loads from 0, 10, 20, 40 % of their bodyweight but an experienced could use 0, 20, 40, 60 and 80%. It is in line with Giroux et al. (2016) who used 0, 10, 20, 30, 40, 50 and 60% of bodyweight to evaluate elite athletes among different sports in SJ. In addition, Jiménez-Reyes et al. (2016) used five to eight loads ranging from 0, 10, 20, 30, 40, 50, 60 %. Another investigation has used four extra loads except for their jump with body weight. (0, 25, 50, 75, 100%) (Jiménez-Reyes et al., 2013) The app *MyJump2* is based on these recommendations and is designed for using four different kind of loads but it should always start with an athlete perform a maximal vertical jump (SJ or CMJ).

We believe that a high amount of load would put excessive unnecessary pressure on joints and muscles throughout the body. In line with ethical considerations we wanted to minimize the risk of injury and we carefully monitored the loads to 0, 20, 40 and 60% of bodyweight since handball players bodyweight are in some cases approximately 100 kg (Ghobadi et al., 2013) We are aware of that method has its constraints and a more valid design is to use a higher amount of loads (e.g. up to 80%) (Morin & Samozino, 2016) but we carefully considered that to an markable increase risk of injury. We believe that if you perform a squat-jump with 80% of body weight on the shoulders the amount of pressure on the players back and knees would be unnecessary demanding.

5.2 Result discussion

It is worth to note that because of a higher body weight (kg) and overall anthropometrics (weight+height) pivots have a lower relative strength (N/kg) compared to wings. (31.884 vs 32.88)

This could be argued that pivots are heavier with the reason of that they need to resist the higher number of contacts compared to wings has been described by Michalsik et al. (2011, 2013). Which also is a possible explanation why they expressed a significantly ($p=0.008$) higher absolute force (F). It seems to require more information to confirm this statement but worth to note is that the wings are significantly faster than pivots (2.85 vs 3.196 m/s) ($p=0.048$) in order to be fast in for example counter attacks.

We expected a significant difference between wings and pivot in force-velocity profiles and the result confirms our hypothesis in jump height (37,906 cm vs 44.05 cm) ($p=0.006$). We think that the reason behind this difference is anthropometrics and specific game demands. Wings need to jump higher when finishing in narrow spaces close to the six meters line and need this ability to increase their chance of scoring. Interestingly, since jump height is correlated with sprint performance (Cronin & Sleivert, 2005; Sáez de Villareal et al., 2012) this could be a reason think that they also would express a better horizontal speed compared to pivots. But this hypothesis needs to be more investigated in detail before we can draw any raw conclusions.

There is no significant ($p=0.349$) % imbalance between our groups (15.492 vs 20.588) and recall that Morin et al. (2016) recommend a limit below 10% if we should consider an athlete balanced between force and velocity. If we only look at our mean values in both groups, we can notice that there is a moderately % imbalance. The reason for this could be that the teams where at different periods of their season. Some testing-procedures were done in the preparation before a possible play offs (before the breakout of COVID-19) and some were performed in their preseason. Usual abstract periodization models include speed-strength and more plyometrics before important games as in play offs and the start of the preseason includes more general and basic strength training. This could possibly affect our results.

Both positions have different mechanics which in turn affecting their jump height. Wings Pmax is highly dependent on velocity compared to pivots who relies more on absolute F. This strengthens our hypothesis that this result reflects the physical performance on the field as recently been described by Cardinale et al. (2017) and Büchel et al. (2019). But this is only on a very abstract level since this test do not cover the whole physical picture. That said, our result is in line with Samozino et al. (2012) proposed theory that Pmax is not the only muscular property involved in jumping performance since our result in velocity and force is different between our groups. We could notice that two individuals with the same Pmax have different performances in jump height. This tell us that they may have an imbalance between force and velocity profiles which in turn inhibits their maximal power output and in turn their jump height. (Morin & Samozino, 2016) On an abstract level and with the result in mind it is possible to think that pivots need emphasize more on velocity-oriented training and wings need the opposite in order to improve Pmax. Because there is a significant difference between position in how they produce their Pmax ($p=0.003$) This information should be considered of greatest interest for coaches who seeking to divide their players into sub-groups with specific focus of force, velocity or combination during physical sessions.

Another key factor that we must carefully consider is that this investigation only reflects the vertical profile of an athlete and not horizontal which could therefore not be used to describe all force vectors of an athletic performance. Our approach has monotonous focus on the lower limb FVP since an optimal balance (FVimb) is strongly related to maximal individual jump height. (Morin & Samozino, 2016; Jiménez-Reyes et al., 2014) Caution should therefore be taken when inferring and assess changes in one skill (e.g. jumping) as a consequence of an improvement in the other (e.g. sprinting). In this case, we encourage the reader to not stare blindly on the vertical profile and design all interventions based on these results.

5.3 Limitations

The investigation has a couple of constraints which could affect the outcomes and possible interpretations thereafter. It does not describe the whole population of elite male handball players in handbollsligan since we only had five participant teams from originally fourteen that were asked. In addition to that, not all players in the participating teams did not complete the test due to injury or illness. Since the test was performed close to playoffs times, many of the participant teams wanted to avoid excessive and unnecessary activities. This resulted in that many of the most valuable and important players did not completed the test and instead the second or third choice on that position were chosen. This gives us reason for claiming that the test does not reflect the best male pivots and wing players in handbollsligan and Sweden. The team's number of players distributed to positions is also varying because that the wing consists of two sides (right and left) compared to pivots who only have a central position which resulted in a small sample of pivots.

The eruption of COVID-19 made our recruitment even more difficult because the Swedish government limited the possibilities of gathering people in public places. This resulted in that the teams from handbollsligan re-booked our test occasions, or even worse, canceling them with the fear of exacerbating the spread of the virus. When we take all these factors together this led to the small selections of only thirteen participant pivots and seventeen wings which cannot be considered to describe the entire league (handbollsligan). It could be advantageously to do this research in the pre-season to exclude the tight game schedule and with the Swedish handball federation consent who have the power to highlight the importance of the study.

We made some technical observations and some possible errors in the testing procedure. First, one player had recently went through two bigger surgeries for ACL reconstruction but were in this test fully recovered. This made the squat jump less effective because we noticed that his take-off was unbalanced due to asymmetries (e.g. dragged behind with one leg) As mentioned before the MyJump app calculates jump height from fly time and when both feet are in the air which is a possible reason why his jump height was very low. Similar obstacles were noted with one another player who jumped very well in his two attempts but didn't jump strictly vertical in the descending movement and instead landed lateral which causes problems when he strike to the ground. Even though our instructions were very clear before execution, we must careful consider our instructions linked to this is execution. Where the instructions well-informed enough or could we have refined it to the player about trying to synchronize both feet in landing? This is obviously an important issue for future practitioners to consider.

5.4 Strengths

We consider the fact of including the two-jump testing on each % of bodyweight to be a strength in our study even though it was time consuming. There is always a possible chance that error could occur during the first attempt (e.g. struggling with recording or incorrect jumping procedure).

Finally, when we spoke to coaches in the participating teams, we notice that there exists a difference in how they coordinate and monitor they are training throughout the season. Some Coaches preferred to do maximal strength, some easier or harder circuits and some just wanted their players to rest mentally and physical. We must be aware of the fluctuations in training load and fitness versus fatigue between our participants could have affected our result. Despite this information from coaches we consider this to be a strength because it was still a significant difference between positions when we compared our variables (Jump height, velocity, absolute force, relative force, Pmax). Even though this is anecdotal evidence that needs further investigations it could still be a sign that it exists many ways to develop skills that is specific to player positions

5.5 Future investigations and considerations

This study focusses on male players and not women. For future research this would be interesting to investigate if there is a similar difference in females between positions as it seems to occur in male. Many of the Swedish clubs operates within both genders and this is an opportunity for them to get another aspect if there exist a difference in how women and men produce their Pmax. If an addition is made with females, we believe that this investigation also could support when designing individualized programs based on genders. It is also worth to note that this descriptive study only investigates vertical relationship between force and velocity. We would like to highlight the importance of adding horizontal profiling in order to create a more robust physical assessment since a handball game includes both vertical and horizontal movements. (Luteberget & Spencer, 2017; Michalsik et al., 2013)

It remains unclear what type of training method that is most effective for team handball players regarding player positions to shift the FVP. For the general population of athletes Suchomel et al. (2017) prescribe a possible intervention with weightlifting derivatives and Morin et al. (2016) prefer a more mixed, individualized method of sprint, jump and weightlifting.

Conclusion

Our main hypothesis was confirmed that it should exist a difference between pivot and wings when we compared relative force, Absolut force, velocity, Pmax and Jump height. But this difference was not statistically significantly on every variable. Most notable is that wings when performing a unloaded and loaded squat jump are better suited to handle their relative strength (N/kg) and is faster (m/s) than pivots. In comparison is pivot stronger when we looking at absolute force which is probably because of the reason that they have to handle the increased amount of body contacts and collisions during match play as earlier described by Michalsik et al. (2011; Ghobadi et al., 2013) A training program should therefore focus on the least developed component in FVP (Cormie et al., 2011b; Samozino et al., 2012) and a player should put extra attention on %imb to switch either force, velocity or Pmax during their physical session in order to maximize their jumping performance. (Morin & Samozino, 2016; Jiménez-Reyes et al., 2016) This study provides scope that it is important to consider playing positions when selecting the most appropriate loads, which mostly target specific areas on the theoretical F-V spectrum and practical load-velocity spectrum: Force, Velocity or Power.

To our knowledge, this is the first-time force-velocity profiling has been analyzed between positions in team handball and this study could therefore highlight the importance of furthermore complex investigations. We hope that this result will draw attention to and highlight the importance of a position-based training programs aiming for develop the specific requirements of pivots and wings in team handball.

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8. Attachments

Information about study

DEPARTMENT OF FOOD AND
NUTRITION, AND SPORT SCIENCE

UNIVERSITY OF GOTHENBURG

Information om forskningsstudien

Vill du delta i en forskningsstudie och vår kandidatuppsats?

Vem kan vara med?
Vi bjuder in dig som är knuten till ett handbollslag i den svenska högsta ligan i handboll och har positionen kantsex eller mittsex samt är av manligt kön (18-35år). Studien handlar om att beskriva de individuella fysiologiska skillnaderna mellan dessa positioner baserat på ett fysiologiskt test. (Force-Velocity Profiling)

Vad går studien ut på?
Handboll är en komplex sport som karaktäriseras av kraftiga start/stopp moment och närkamper samtidigt som du skall förstå idrottens taktik och teknik. På grund av idrottens ekonomiska verklighet tenderar den fysiska träningen att bli kollektivt utformad och inte baserad på individens unika behov eller positionens kravprofil under match.
Studiens syfte är att undersöka om det är en skillnad i positionerna baserat på ett test (kraft-hastighets profilering) likt de olikheter som uppstår i rörelsemönstret under match. Testet har visat sig kunna vägleda tränare att placera spelare i sub-grupper om hastighet, kraft eller en kombination av dessa två för att förbättra den fysiologiska kapaciteten.
Målet är att kunna beskriva de fysiologiska individuella skillnader och förhoppningsvis öka förståelsen för tränare när de skapar träningsprogram.

Vad skall ni göra om ni är med?
Ditt deltagande kommer att kräva att du har minst 1 års vana av styrketräning med specifik inriktning emot knäböj och skall inte ha några symptom på skada. Du har heller inte utfört en maximal ansträngning 2 dygn före testdagen.
Testet kommer att genomföras under totalt 25 minuter fördelar på 10 min standardiserad uppvärmning, 5 minuters introduktion, 10 minuters utförande av test. Du kommer att få utföra vertikalhopp om 1 reps på 0%, 20%, 40% och 60% av din kroppsvikt med skivstång. Du kommer också att få 2 minuters vila mellan set och behöver vara ombytt i bekväma träningskläder. Tydliga instruktioner om testets utförande för att minimera risker kommer att kommuniceras.

Deltagande och resultat är anonyma
Alla resultat och ditt deltagande i studien är strikt anonyma. När resultatet presenteras i kandidatuppsatsen kommer ni att kategoriseras anonymt utefter er position. Ingen kommer därför få veta vilket resultat som tillhör vem.
All data kommer endast att förvaras hos oss (Pontus Axell & Kalle Öberg), används endast till studiens syfte och delas inte med till någon annan. Om du som deltagare vill få reda på ditt personliga resultat eller ta del av kandidatuppsatsen kan det godtas emot önskemål.

Finns det några nackdelar med att vara med?
Metoden har använts vid flera tidigare forskningsprojekt och anses vara en tillförlitlig samt enkelt tillvägagångssätt i att utvärdera kraft-hastighets profiler hos idrottare. Det finns dock en minimal risk att individen kan ta skada och därför kommer vi vid minsta antagande avbryta studien om risk för detta förefaller. Om individen dessutom uppvisar en otillräcklig teknik utesluts den direkt från deltagande.

Finns det några fördelar med att vara med?
Du bidrar med ditt deltagande till handbollens utveckling emot att vi tidigare kan träna individer utefter deras roll på planen samt underlätta bedömningen till var han befinner sig sin fysiologiska utveckling. Förhoppningen är att resultatet skall kunna hjälpa tränare att vägleda och individualisera träningen samt därigenom få individer att nå sin maximala potential snabbare.
Du kommer efter avslutat test få tillgång till ditt individuella resultat samt vägledning hur du skulle kunna träna baserat på det. På önskemål går det även att få ta del av studiens hela resultat.

Om du ångrar dig och inte vill vara med?
Du kan när som helst avbryta ditt deltagande oberoende om detta sker före, under eller efter testet. Du behöver inte berätta för någon om din anledning och ingen kommer heller att fråga dig om det.

Vem gör den här forskningen?
Pontus Axell & Kalle Öberg som är Sports Coaching studenter med inriktning idrottsvetenskap vid Göteborgs Universitet

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Vi frågor får ni gärna kontakta någon av ovanstående.

Written Consent:

DEPARTMENT OF FOOD AND NUTRITION, AND SPORT SCIENCE

UNIVERSITY OF GOTHENBURG

Samtyckesformulär

Samtycke till att delta i studien

Jag har fått information muntligt om hur studien kommer gå till. Jag har även haft möjlighet att ställa frågor. Jag har fått möjlighet att behålla informationen skriftligt.

Jag samtycker till att delta i studien om…

Jag samtycker till att uppgifter om mig behandlas enligt forskningsprocessinformationen som jag blivit tilldelad.

Jag är medveten om att jag när som helst under studiens gång kan välja att avbryta mitt deltagande.

Plats & datum:	Underskrift:

Warm-up Protocol:

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Warm up protocol

Goal: Maximize preperations before four squat jumps with progressive loads.
Duration: 10 min

Part 1

Cycling 3 min with 60-70% of self-perceived maximal effort

Part 2

Dynamic Mobility: 3 min consisting of
- Half pigeon 2x6sec/leg

- Garland pose (deep squat position) 3x10sec (put pressure on each joint and ankle)

Garland Pose

Part 3

Strength and power drills: 3 min consisting of

- Backsquat with 50% of their 1RM 1x3 reps
- Maximum repeated CMJ 2x2 reps (rest 1 min between each set)