

## BILATERAL COUNTERMOVEMENT JUMP SQUAT JUMP ECCENTRIC UTILIZATION RATIO AND DROP JUMP PERFORMANCE OF MALE HANDBALL PLAYERS: AN OVERVIEW OF POSITIONAL DIFFERENCE

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### Abstract

**Background:** Handball (HB) is fast intermittent body contact sports demands all domains of fitness. Understanding the fitness level of a handball player can determine their capability that assist coaches and strength and conditioning expert in designing appropriate training programme. Studying the vertical jumping ability difference among university (Annamalai University & Bharathidasan University) male handball (HB) players with respect to position of playing (playing position) is required. Therefore, the aim was to compare bilateral countermovement jump (CMJ), squat jump (SJ), eccentric utilization ratio (EUR), and drop jump (DJ) performance of university male handball (HB) players with reference to position of playing and secondary aim was to compute the jump height variations between CMJ and SJ performance of university male HB players with reference to specific game positions.

**Methods:** Thirty-nine (39) university male handball players were identified and recruited as subjects by random sampling. These selected subjects were divided into four groups in relation to playing position as backcourt players (BC), wing players (W), pivot players (P), and goal keeper (GK). Bilateral CMJ, SJ and DJ data were collected using OPTOJUMP (Microgate S.r.l, Bolzano, Italy).

**Results:** ANOVA showed that CMJ – flight time (FT) & jump height (JH), SJ - FT & JH, DJ - FT, JH, & reactive strength index (RSI) displayed a significant difference among handball players. BC and W players found to be better in CMJ, SJ, and DJ but P players found inferior to others. The paired t test highlighted significant difference between CMJ and SJ jump height in BC, W, P, GK and total (T) players.

**Conclusion:** The playing position differences in jumping ability (CMJ, SJ, DJ) is witnessed among university male handball players. The secondary aim proves the eccentric action in CMJ benefited to jump higher than SJ in handball players. These findings clearly project the importance of designing handball specific training goals for handball players with position wise to enhance their vertical jump performance and prevent injury.

**Keywords:** Optojump, Jump, Flight time, Contact time, reactive strength index, Power

### Introduction

Handball indeed requires a dynamic blend of physical attributes for athletes to excel. Strength, power, speed, and agility are critical components that plays a crucial role in competition for triumph of handball players (Luteberget, Spencer, 2017; Luteberget, Trollerud, Spencer, 2018; Manchado, Tortosa-Martínez, Vila, Ferragut, Platen, 2013; Pérez Armendáriz, Spyrou, Alcaraz, 2024; Michalsik, Madsen, Aagaard, 2014). Testing their physical qualities will guide the coaches to formulate specific training programs to overcome their weakness and prevent injuries. Enhancing these attributes are especially vital for handball players as it supports their overall growth and performance during sixty minutes game (Chaabene et al., 2020; Gaamouri et al., 2023; Hammami et al., 2021).

Earlier research studies had compared the anthropometric characteristics, morphological, physical fitness, and physiological parameters for handball players with respect to playing positions. Analysing players capacity position wise will assist coaches and sports scientist in identifying talents, determines strength, weakness, and design specific conditioning programmes (Karcher & Buchheit, 2014; Fieseler, Hermassi, Hoffmeyer, and others, 2017; Schwesig, Hermassi, Fieseler, and others, 2017). In soccer kinanthropometric, physical, & physiological capacity of players varies across playing position (Karcher and Buchheit, 2014) and studies reported that handball players also exhibited significant differences on physiological and physical attributes (Srhoj, Marinović, Roguli, 2002; Šibila, et al., 2009; Zapartidis, Koroasos, Christodoulidis, et al., 2011; Chittibabu 2014a; Chittibabu 2014b; Rousanoglou, Noutsos, et al., 2014).

Physical and physiological testing started from playfield and progressed to laboratory for more scientific and accurate measurement. Coaches and health professional understood the positive outcomes of measuring vertical jumping ability (Manno, 2008; Seitz, Reyes, Haff, Tran, Saez de Villarreal, 2014; Spiteri, Nimphius, Hart, Newton, Specos, Sheppard, 2014; Suchomel, Nimphius, Stone, 2016; Duthie 2006). Stretch-shortening cycle (SSC) phenomena is commonly noted in human movements (jumping, running, throwing, etc.,) which are identified as performance augmenting mechanism (Bosco et al., 1981; Seiberl, Power, Herzog, Hahn, 2015).

Established CMJ, SJ, and drop jump test is to measure lower extremity explosive power, and reactive strength. Stretch shortening cycle comprises of eccentric, amortisation, and concentric phase, SSC begins with high intensity eccentric contraction followed by minimal coupling time and rapid concentric contraction during CMJ and DJ but in SJ has only concentric phase (Hasan 2023). Vertical jump performance can be measured using contact mats (jump height measured using flight time), force platforms (jump height measured when force is exerted during jump), IMU (jump height measured based on orientation of segment), high-speed cameras (jump height measured using captured detailed motion analysis), and infrared platforms (jump height measured using light sensors) have demonstrated as a valid and reliable measure for vertical jump performance. Jump related studies in handball players with respect to position of playing is relatively scarce and possess some discrepancies. Addressing the research gap in jump performance of handball players following aims are formulated. The primary aim was to compare bilateral CMJ, SJ, EUR, and DJ performance of university male handball players with reference to position of playing and secondary purpose was to compute the jump height difference between CMJ and SJ of university male handball players with reference to playing positions. We hypothesized that bilateral CMJ, SJ, EUR, and DJ performance significantly different among university male handball players with relevance to position of playing. Secondly, CMJ - jump height and SJ - jump height significantly differ among university male handball players with reference to players playing positions.

## Methods and Equipments

### Subjects

Thirty-nine (39) university male handball players (age:  $21.66 \pm 1.59$  yr, body mass:  $71.30 \pm 6.33$  kg, stature:  $177.28 \pm 2.47$  cm) were designated at random as subjects. These nominated handball players were grouped into four (04) groups based on their playing position as back court players ( $n = 12$ , age:  $21.41 \pm 1.62$  yr, body mass:  $72.33 \pm 4.07$  kg, stature:  $178.5 \pm 1.83$ cm), wing players ( $n = 10$ , age:  $21.30 \pm 1.88$  yr, body mass:  $66.20 \pm 4.21$  kg, stature:  $175.3 \pm 2.35$ cm), pivot players ( $n = 10$ , age:  $21.90 \pm 1.37$  yr, body mass:  $78.8 \pm 2.97$  kg, stature:  $178.3 \pm 1.33$ cm) and goalkeeper ( $n = 07$ , age:  $22.28 \pm 1.49$  yr, body mass:  $66.14 \pm 3.71$  kg, stature:  $176.57 \pm 3.10$ cm). These subjects agreed to voluntarily participate in this study and gave consent both verbally and in written. These subjects were informed about this study and they can also withdraw from the study at any point of time.

### Materials

Lower-limbs explosive power (flight time, height of leaps, and contact time) was estimated by performing a bilateral countermovement jump, a squat, and a drop jump using OPTOJUMP (Microgate S.r.l, Italy) (Attia et al., 2016).

### Jump tests

Bilateral CMJ, SJ and DJ data were collected using OPTOJUMP (Microgate S.r.l, Italy). Handball players had dynamic warm-up before testing CMJ, SJ and DJ and followed by dynamic warm-down. The subject was instructed step between transmitter (Tx) and receiver (Rx) placed 6m apart. On command go subjects performed CMJ, SJ and DJ followed by sufficient recovery to prevent fatigue that hampers their jump performance.

- **Countermovement Jump:** This involves starting from an upright position, quickly flexing the knees between  $90^\circ$  to  $100^\circ$  angle, and rapidly jump higher. In CMJ rapid bending and straightening of the knees help in engaging the stretch-shortening cycle of the muscles, which can test explosive power. They performed three CMJ with an arm swing.
- **Squat Jump:** Participants start by bending their knees to a  $90^\circ$  angle before jumping. After bending the knee to  $90^\circ$  they stabilize for 2-3 second and the jump was performed without countermovement (Coratella et al., 2018). They performed three SJ with arms on the hips.
- **Drop Jump:** Subjects performed three trials standing feet apart on the box of 45cm height. The subjects jumped forward between transmitter (Tx) and receiver (Rx) of OPTO JUMP and upon landing they jump rapidly vertical in the air and they should not flex their knee while jumping they can open their arm (Beardt et al., 2018). The box is placed between transmitter (Tx) and receiver (Rx) which should not hinder these two sensors.

RSI is calculated by jump height divided by foot contact time. Eccentric utilization ratio was calculated by CMJ height divided by SJ height. Intra-class correlation coefficients (ICCs) of jump height of 0.789 for the countermovement jump (CMJ), 0.796 for SJ, and 0.798 noticed for DJ.

### Research Design and Sampling Technique

Research design is a comprehensive plan that outlines the systematic and scientific methods employed in conducting this study. Handball players were selected randomly as sample, these samples are true representation of the population. This was done by adopting an approach in selecting the subset of target population volunteered to participate in this study.

### Statistical Procedures

SPSS (SPSS Company, America, version 16.0) was used for the purpose of analysing the data on selected variables by ANOVA (Analysis of Variance) that explore the difference

between the groups (BC, W, P, & GK). If obtained 'F' value is significant, Scheffe's posthoc test was administered to estimate the paired mean difference. Further, to analyse the variations between CMJ and SJ on jump height paired t test was administered. The alpha [ $\alpha$ ] value was set at 0.05 for statistical significance.

### Results

ANOVA elicited significant difference between groups (Backcourt players, wing players, pivot players, & goalkeeper) in CMJ - flight time [ $F(3,35) = 5.847, p = .002$ ; Scheffe's post test: BC vs. P ( $p = 0.014$ ), W vs. P ( $p = .018$ ), and P vs. GK ( $p = 0.023$ )] and CMJ – jump height [ $F(3,35) = 3.742, p = 0.020$ ; Scheffe's post hoc test: BC vs. P ( $p = 0.027$ )] (Table 1). However, other comparison failed to show significant difference ( $p > 0.05$ ).

Table 1: Vertical Jumping ability among university HB players

| Variables         | Handball Players Position wise |                 |                 |                  |                 | F value | p value | Scheffe's post hoc test |                             |           |                            |          |                             |  |
|-------------------|--------------------------------|-----------------|-----------------|------------------|-----------------|---------|---------|-------------------------|-----------------------------|-----------|----------------------------|----------|-----------------------------|--|
|                   | BC<br>(n = 12)                 | W<br>(n = 10)   | P<br>(n = 10)   | GK<br>(n = 07)   | T<br>(n = 39)   |         |         |                         |                             |           |                            |          |                             |  |
| <b>CMJ</b>        |                                |                 |                 |                  |                 |         |         |                         |                             |           |                            |          |                             |  |
| Flight time (s)   | 0.6382 ± 0.0515                | 0.6390 ± 0.0422 | 0.5590 ± 0.0530 | 0.6443 ± 0.0670  | 0.6192 ± 0.0620 | 5.847   | 0.002   | BC vs. W                | <b>BC vs. P<sup>†</sup></b> | BC vs. GK | <b>W vs. P<sup>†</sup></b> | W vs. GK | <b>P vs. GK<sup>†</sup></b> |  |
| Jump Height (cm)  | 54.875 ± 5.4191                | 52.820 ± 7.8963 | 43.880 ± 8.9456 | 51.214 ± 10.3286 | 50.871 ± 8.8324 | 3.742   | 0.020   | BC vs. W                | <b>BC vs. P<sup>†</sup></b> | BC vs. GK | W vs. P                    | W vs. GK | P vs. GK                    |  |
| <b>SJ</b>         |                                |                 |                 |                  |                 |         |         |                         |                             |           |                            |          |                             |  |
| Flight time (s)   | 0.5118 ± 0.0404                | 0.5488 ± 0.2853 | 0.4880 ± 0.3255 | 0.5094 ± 0.3773  | 0.5148 ± 0.0405 | 5.120   | 0.005   | BC vs. W                | BC vs. P                    | BC vs. GK | <b>W vs. P<sup>†</sup></b> | W vs. GK | P vs. GK                    |  |
| Jump Height (cm)  | 31.541 ± 4.1472                | 35.454 ± 3.3364 | 29.320 ± 3.8704 | 31.974 ± 4.4453  | 32.052 ± 4.4018 | 4.160   | 0.013   | BC vs. W                | BC vs. P                    | BC vs. GK | <b>W vs. P<sup>†</sup></b> | W vs. GK | P vs. GK                    |  |
| <b>EUR</b>        | 1.7725 ± 0.3230                | 1.5020 ± 0.2720 | 1.5290 ± 0.4114 | 1.6429 ± 0.4625  | 1.6174 ± 0.3672 | 1.274   | 0.298   | BC vs. W                | BC vs. P                    | BC vs. GK | W vs. P                    | W vs. GK | P vs. GK                    |  |
| <b>DJ (45 cm)</b> |                                |                 |                 |                  |                 |         |         |                         |                             |           |                            |          |                             |  |
| Flight time (s)   | 0.6494 ± 0.0641                | 0.6268 ± 0.0866 | 0.5540 ± 0.0440 | 0.6471 ± 0.0655  | 0.6187 ± 0.0753 | 4.447   | 0.009   | BC vs. W                | <b>BC vs. P<sup>†</sup></b> | BC vs. GK | W vs. P                    | W vs. GK | P vs. GK                    |  |
| Contact time (s)  | 0.3818 ± 0.0844                | 0.3329 ± 0.0723 | 0.3856 ± 0.0522 | 0.3357 ± 0.0854  | 0.3619 ± 0.0756 | 1.418   | 0.254   | BC vs. W                | BC vs. P                    | BC vs. GK | W vs. P                    | W vs. GK | P vs. GK                    |  |
| Jump Height (cm)  | 53.150 ± 9.0255                | 48.850 ± 12.924 | 40.702 ± 3.2505 | 51.528 ± 10.517  | 48.564 ± 10.375 | 3.446   | 0.027   | BC vs. W                | <b>BC vs. P<sup>†</sup></b> | BC vs. GK | W vs. P                    | W vs. GK | P vs. GK                    |  |
| Power (Watts)     | 42.817 ± 8.5332                | 43.267 ± 10.945 | 44.532 ± 7.3542 | 39.022 ± 19.206  | 42.691 ± 11.134 | 0.335   | 0.800   | BC vs. W                | BC vs. P                    | BC vs. GK | W vs. P                    | W vs. GK | P vs. GK                    |  |
| RSI               | 1.7983 ± 0.3841                | 1.7370 ± 0.3878 | 1.3270 ± 0.1548 | 1.7743 ± 0.4655  | 1.6574 ± 0.3967 | 3.866   | 0.017   | BC vs. W                | <b>BC vs. P<sup>†</sup></b> | BC vs. GK | W vs. P                    | W vs. GK | P vs. GK                    |  |

<sup>†</sup>p < 0.05 level; BC – Back court player, W – Wing player, P – Pivot player, GK – Goalkeeper, T – Total,

Table 1 also show a statistically significant difference among groups (Backcourt players, wing players, pivot players, & goalkeeper) in SJ - flight time [ $F(3,35) = 5.120$ ,  $p$  value = 0.005; Scheffe's post hoc test (comparison between playing position): W vs. P ( $p = 0.006$ )], SJ – jump height [ $F(3,35) = 4.160$ ,  $p = .013$ ; Scheffe's post test: W vs. P ( $p = 0.014$ )]. However, other comparison failed to show significant variations ( $p > 0.05$ ). In contrast to CMJ and SJ, eccentric utilization ratio also failed to show a significant difference among handball players [ $F(3,35) = 1.274$ ,  $p = 0.298$ ].

Similarly, DJ – flight time had a statistically significant difference among groups [ $F(3,35) = 4.447$ ,  $p = 0.0020$ ; Scheffe's post test: BC vs. P ( $p = 0.020$ )], DJ – jump height [ $F(3,35) = 3.446$ ,  $p = .027$ ; Scheffe's post test: BC vs. P ( $p = 0.038$ )], and DJ – RSI [ $F(3,35) = 3.866$ ,  $p = 0.017$ ; Scheffe's post test: BC vs. P ( $p = 0.037$ )]. Further, other Scheffe's post test pairwise comparison failed to show statistically significant difference ( $p > 0.05$ ). However, DJ – contact time [ $F(3,35) = 1.418$ ,  $p = 0.254$ ], and DJ – power [ $F(3,35) = 0.335$ ,  $p = 0.800$ ], failed to show significant variations among university male HB players with relevance to players position (Table 1).

Table 2 presents the descriptive and difference of jump height between CMJ and SJ in male university handball players is noted within all playing position and total. The paired t test highlighted significant difference in jump height between CMJ and SJ in BC, W, P, GK and T players.

**Table 2: Difference in Jump height (CMJ vs. SJ) in handball players**

| Handball players | Testing Variables | Mean $\pm$ SD          | t value       | p value      |
|------------------|-------------------|------------------------|---------------|--------------|
| BC (n =12)       | CMJ               | 54.8750 $\pm$ 5.41918  | <b>12.236</b> | <b>0.000</b> |
|                  | SJ                | 31.5417 $\pm$ 4.14723  |               |              |
| W (n =10)        | CMJ               | 52.8200 $\pm$ 7.89638  | <b>6.236</b>  | <b>0.000</b> |
|                  | SJ                | 35.4540 $\pm$ 3.33641  |               |              |
| P (n =10)        | CMJ               | 43.8800 $\pm$ 8.94561  | <b>4.318</b>  | <b>0.002</b> |
|                  | SJ                | 29.3200 $\pm$ 3.87042  |               |              |
| GK (n =07)       | CMJ               | 51.2143 $\pm$ 10.32867 | <b>4.436</b>  | <b>0.004</b> |
|                  | SJ                | 31.9743 $\pm$ 4.44539  |               |              |
| T (n =39)        | CMJ               | 50.8718 $\pm$ 8.83244  | <b>12.352</b> | <b>0.000</b> |
|                  | SJ                | 32.0528 $\pm$ 4.40189  |               |              |

CMJ – Countermovement jump, SJ – Squat jump, BC – Back court player, W – Wing player, P – Pivot player, GK – Goalkeeper, T – Total,

## Discussion

In the present findings, playing position wise difference is noticed in vertical jump performance. Bilateral or unilateral vertical jump shot and blocks are important skill movement noticed during the match (Póvoas et al., 2014). CMJ, SJ and DJ performance was dominated by BC and W players and better than goal keeper, and pivot players. The present result is in line with the results of Krüger and his colleagues (2014); Haugen and his colleagues (2016); Havolli and his associates (2020). This difference are attributed to several neurophysiological mechanisms like storage of elastic energy in muscle (Turner & Jeffreys, 2010; McBride, McCaulley, Cormie, 2008), reflex (involuntary) nervous processes (Turner & Jeffreys, 2010; Bosco and his partners 1987), muscle active state (Turner & Jeffreys, 2010; Bobbert, and his associates 1996), muscle length-tension characteristics (Ettema and his colleagues 1992; Turner & Jeffreys, 2010; Finni and his colleagues 2001), muscle pre-activity tension

(Kyrolainen, Komi, Kim, 1991; Turner & Jeffreys, 2010; Schmidtbleicher, Gollhofer, Frick, 1988), and enhanced muscle motor coordination (Turner & Jeffreys, 2010) contributes to SSC.

The eccentric and concentric phases in CMJ seems to be dominant than SJ which has only concentric phase. The effective use of eccentric phase activates muscle lengthening which are passive (Turner & Jeffreys, 2010) leads to increase in residual force or potentiation (Ettema et al., 1992; Herzog 2014). The observation clearly show that CMJ produces greater jump height than SJ. CMJ recruits more muscle fibers which store and utilization of elastic during eccentric phase (downward movement) leading to larger power output with negligible amortization phase. The present study also showed RSI difference between groups, where BC players are better than pivot players. Back court players have better transformation from rapid eccentric to rapid concentric contraction. Monitoring and improving RSI will contributes to efficiency to jump higher, sprint faster, and quick change of direction in HB players and also minimize the risk of injury (Flanagan & Comyns 2008).

### Conclusion

This study shows that pivot players were outperformed by backcourt players, wing players, and goalkeeper in flight time, jumping ability, and RSI in university male handball players. This screening clearly emphasis that explosive training and strength training must be prescribed to pivot players to enhance their jumping ability and reactive strength. The rapid eccentric-concentric contraction in CMJ provides advantage over concentric contraction in SJ. The insight of the present report proves that CMJ, SJ & DJ test are means to measure their explosive power and reactive strength of handball players. This study also clearly demonstrated the importance of jump performance among handball players. The findings clearly emphasize the importance of designing handball specific training programs for players with position wise to enhance their vertical jump performance and prevent injury. This study result suggest that the study can be extended based on gender, playing experience, and level of competition.

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