

ORIGINAL ARTICLE

Influence of Body Mass Index and Body Weight on Single-Hop Test Outcomes in an ACL Sport Rehabilitation Program: A Cross-Sectional Study

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ABSTRACT

Background & Objectives: Body mass index (BMI) and body weight may influence recovery following anterior cruciate ligament (ACL) injuries, yet their relationship to functional rehabilitation outcomes remains unclear. **Objective:** To examine the association between BMI, body weight, and performance in the Single Hop Test (SHT) among individuals undergoing an ACL sport rehabilitation programme. **Methods:** A cross-sectional study was conducted among patients aged 18–60 at the Physiotherapy Unit, Queen Elizabeth II Hospital. BMI and body weight were recorded at the end of the rehabilitation phase, and functional performance was assessed using the SHT. Statistical analysis included Shapiro–Wilk tests for normality and Pearson’s correlation to evaluate associations between anthropometric variables and test performance. **Results:** BMI showed a modest, statistically significant negative correlation with SHT performance, whereas body weight was not significantly associated with SHT outcomes. **Conclusion:** BMI may exert a minor but meaningful influence on functional recovery after ACL rehabilitation, while absolute weight alone is less predictive. These findings support integrating BMI control considerations into rehabilitation planning to optimise outcomes.

Keywords: BMI, body weight, ACL rehabilitation, Single Hop Test, sports injury

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INTRODUCTION

Anterior cruciate ligament (ACL) injuries are a major concern in sports and physical activity, affecting approximately 200,000 people annually (Waldron et al., 2022). In Malaysia, cases have been documented in hockey, kick volleyball, and netball (Damanhuri, 2017), and professional athletes are particularly at risk in high-demand sports such as football and skiing (Mara et al., 2019). Studies across diverse populations have shown inter-ethnic differences in ACL injury characteristics (Ahdén et al., 2012; Fok & Yau, 2015; John et al., 2016; Leathers et al., 2015; Lind, Menhert, & Pedersen, 2009; Lyman et al., 2009; Mei et al.), highlighting the influence of genetic, environmental, cultural, and lifestyle factors.

ACL injuries often occur during pivoting, braking, or high-impact movements (Casado et al., 2019; Maria et al., 2019) and may require surgical intervention (Jay, 2021; Lestari et al., 2020). Obesity and high BMI have been identified as independent risk factors for

musculoskeletal injuries, including ACL damage (Bojicic et al., 2017), with higher BMI potentially increasing the risk of reinjury post-rehabilitation (Lestari et al., 2020).

The Single Hop Test (SHT) is a reliable and widely used functional assessment in ACL rehabilitation, allowing clinicians to track progress and readiness for return to sport. It is not a novel metric, but an adaptation of pre-existing functional testing methods utilized in sports medicine. The test has evolved from numerous hop-and-jump evaluations commonly acknowledged in the literature for assessing athletic performance and rehabilitation after lower limb injuries (Gokeler et al., 2016). Advanced research has aimed to standardize the implementation of hop tests, including the Single Hop Test, rendering it a crucial element of return-to-sport protocols following ACL reconstruction. This standardization enables medical professionals to evaluate performance indicators like the LSI, which indicates the comparative performance of the wounded leg vs the uninjured limb, hence informing rehabilitation (Toole et al., 2017; Kotsifaki et al., 2022). It is frequently

used as a rapid, efficient assessment of an athlete's functional capacity following rehabilitation. A limb symmetry index (LSI) on SHT of 90% is a standard benchmark to show that someone is ready to return to sports (Kotsifaki et al., 2019; Davies et al., 2019). Research shows that numerous athletes can gradually undergo hop testing as soon as six months post-surgery if they achieve an LSI of 90% or more in strength measurements, such as isokinetic testing. Grindem et al. state that successful SHT completion is strongly associated with lower reinjury rates (Grindem et al., 2016). Furthermore, Panjwani et al. advocate for the efficacy of standardized tests, such as the SHT, as essential metrics for determining RTS decisions (Panjwani et al., 2025). Studies have shown that hop performance symmetry predicts recovery and preparation for competitive sports (Yao et al., 2020; Schmitt et al., 2022).

However, SHT must meet certain clinical requirements before it can be used to make sure it is safe and useful. The LSI is a very important factor because it compares the injured limb's strength and function with those of the healthy limb. To be considered strong, the LSI must be more than 90% in both quadriceps strength and success on single-legged hop tests (Wellsandt et al., 2017; Kotsifaki et al., 2019). This standard aligns with recommendations for returning to high-level tasks after ACL rehabilitation (Welling et al., 2018; Burgi et al., 2019). In addition, consensus agrees that to reduce the risk of injury, it's important to reach a certain level of strength, such as an LSI of 70% or higher for both the extensor and flexor muscle groups (Burgi et al., 2019). A full evaluation of knee range of motion (ROM) must also be part of the post-surgery healing process. Before doing the SHT, the knee usually needs to bend and straighten at least 95% as far as it can on the healthy leg. Rambaud et al. (2018) say that a limited range of motion (ROM) can be a sign of poor functional recovery and a higher chance of re-injury.

Understanding the relationships among BMI, body weight, and SHT performance could enable physiotherapists to tailor interventions, set realistic recovery goals, and optimise rehabilitation protocols to improve outcomes. This study aims to examine these relationships in patients undergoing ACL sport rehabilitation at Queen Elizabeth II Hospital.

METHODS

Study Design and Participants

A cross-sectional study was conducted among patients aged 18–60 years undergoing ACL sport rehabilitation at the Physiotherapy Unit, Queen Elizabeth II Hospital. Purposive sampling was applied to recruit participants who had completed the return-to-sport phase of rehabilitation.

Measurements

BMI and body weight were recorded at the end of rehabilitation. BMI was calculated using the standard formula (kg/m^2). Functional performance was assessed using the SHT, a validated return-to-sport clearance tool (Hsu et al., 2018). Numerous studies have shown that the SHT is feasible, suggesting it can be used in real-life settings. Grindem et al. reported that SHTs are essential for evaluating knee function and are regularly included in test batteries used to track ACLR rehabilitation. These hopping tests are simple, which makes them easy to use in both clinical and sports rehabilitation settings. Grindem et al. (2016). Nielsen et al. further substantiated the use of these tests by highlighting the critical role of hop tests in return-to-sport procedures post-ACLR, demonstrating their efficacy in predicting successful reinstatement to prior athletic performance levels (Nielsen et al., 2024). Cristiani et al. also noted that SHT is a reliable measure of an athlete's confidence, neuromuscular control, and overall functional ability. These tests have been shown to be reliable for predicting a return to preinjury levels of sports activity after ACLR (Cristiani et al., 2021). Moreover, Cristiani et al. observed that the single hop test effectively reflects an athlete's confidence, neuromuscular control, and overall functional capacity. Importantly, these tests were shown to be reliable at predicting return to preinjury levels of sport participation among patients who had undergone ACLR (Cristiani et al., 2021). Qualified healthcare experts usually do the SHT. In this study, the physiotherapist performs it because they are trained to evaluate functional performance. The test administrators must be able to assess both the distance of the hop and the biomechanics of the movement, looking for good landing mechanics and any compensatory strategies that may emerge throughout the test (Sanders et al., 2016). A comprehensive evaluation by qualified professionals assists in detecting any lingering dysfunctions or asymmetries that may signify a risk of re-injury (Wellsandt et al., 2017; Ebert et al., 2021). In clinical research environments, trained researchers may conduct SHT, following particular protocols outlined in studies designed to assess the efficacy of rehabilitative therapies following ACLR (Chmielewski et al., 2024). The participation of both clinical and scientific experts ensures that the single-hop test serves as a reliable and valid indicator of functional recovery.

This research regulated and controlled variables using conventional clinical protocols, stringent participant selection, and specific measuring instruments to ensure data dependability. Body weight was measured with dependable scales, and height was assessed to compute BMI using a standardized calculator; these measurements were conducted by qualified physiotherapists with equipment presumed to be accurately calibrated to reduce human error. The Single Hop Test (SHT) adhered to standardized protocols, using the non-injured leg as a reference to calculate the Limb Symmetry Index (LSI), with results systematically

documented at the end of the return-to-sport rehabilitation phase. Confounding variables were mitigated by purposive sampling of persons aged 18 to 60 referred for ACL rehabilitation, along with stringent exclusion of participants with pre-existing chronic conditions, non-compliance with the program, or incomplete data. The study ensured uniformity by assuming that all participants underwent standardized rehabilitation at Queen Elizabeth II Hospital and provided accurate medical histories. Data quality was ultimately assessed using normality tests, including the Kolmogorov-Smirnov and Shapiro-Wilk tests, to ensure the integrity of the statistical analysis.

Safety standards for the Single Hop Test (SHT) were incorporated into the study's stringent participant screening and standardized clinical procedures to ensure patient safety. Eligibility for participants was contingent upon their enrolment in the return-to-sport phase of rehabilitation. Safety was further guaranteed by excluding patients with pre-existing chronic diseases, such as cardiovascular or neurological disorders, which could adversely affect rehabilitation outcomes or elevate injury risk. Furthermore, any subject who experienced discomfort or other obstacles that hindered their safe completion of the exam was excluded from the study. The testing approach was carried out by trained physiotherapists, adhering to standardized protocols to ensure proper calibration of the apparatus and correct execution of the technique. SHT is conducted three times, with the best result being selected. The operation adhered to the normal routine care protocols for ACLR rehabilitation at the Physiotherapy Unit of Queen Elizabeth II Hospital. The test is deemed valid only if the participant lands in a controlled fashion, maintains balance without using their arms or the opposite leg to touch the floor, and executes an additional brief hop post-landing. Participants are permitted to conduct practice trials for each limb to ensure familiarity with the task before formal data collection. Participants must commence with their lead toe positioned behind a designated line and leap as far forward as possible, landing on the same limb. The distance is measured from the starting line to the participant's heel, usually recorded to the closest centimeter. The outcomes are represented as a percentage calculated using the LSI method, which involves dividing the distance of the injured leg by the distance of the non-damaged leg and multiplying the result by 100. An LSI greater than 90 is the designated threshold for assessing whether a patient has attained sufficient functional symmetry for "return-to-sport" clearance. This threshold is predicated on the premise that attaining a high level of symmetry between the injured and uninjured limbs is crucial for reducing the likelihood of reinjury (Wellsandt et al., 2017; Kotsifaki et al., 2019). As a researcher, utilizing a benchmarking strategy that utilizes the healthy leg as a benchmark aids in mitigating individual variances, such as stature and baseline strength, which would otherwise complicate the interpretation of absolute distance

data.

Instruments and Tools

A calibrated weight scale and BMI calculator were used for anthropometric measurements. Medical records confirmed ACL injury diagnosis, rehabilitation history, and eligibility. The researcher controlled for assessor bias by using methodological controls and the standards of Queen Elizabeth II Hospital's Physiotherapy Unit. The researcher considered that all rehabilitation and testing methods were uniform and standardized across the participant cohort, attributing functional outcomes to physical characteristics rather than to alterations in clinical practice. The study required certified physiotherapists to measure and assess using calibrated, dependable equipment to ensure data integrity. Most of the data were collected retrospectively from medical records, minimizing active-intervention bias, as the procedures were routine.

Measurement Protocols

The researcher presents a systematic summary of the measuring protocols by amalgamating institutional clinical standards with evidence-based practices identified in the current literature. The SHT, the main outcome, is an objective functional test of lower limb strength and power performed after the return-to-sport rehabilitation period. This protocol includes standardized instructions for performing the task, the use of specific distance markers, and the recording of the distance the participant has travelled. To substantiate the validity of this measure, the researcher references Ithurburn et al. (2019), who identified the SHT as a dependable metric of knee-related functional performance. The researcher also recognizes the value of qualitative scoring methods, as those described by Di Paolo et al. (2022), for evaluating movement quality and landing mechanics. For body mass index (BMI) and weight, anthropometric procedures require only one measurement upon completion of the rehabilitation program. The researcher cites Hsu et al. (2018) to explain why they are focusing on how BMI-related factors affect quadriceps symmetry and functional results. They get this data from credible scales and BMI calculators. The study predominantly relies on retrospective examination of medical records; however, the uniformity of these protocols is upheld by the methodological presumption that all procedures are performed by certified physiotherapists using accurately calibrated equipment within a standardized clinical setting.

Ethical Considerations

Ethical Exemption approval was obtained from the UiTM Research Ethics Committee and Ethical Approval from the Ministry of Health (MREC) number NMRR ID-23-03482-MGL (IIR).

Statistical Analysis

SPSS version 29 was used. Descriptive statistics were expressed as mean \pm standard deviation (SD).

Normality was assessed using the Shapiro–Wilk test (Pontillo et al., 2021). Pearson’s correlation coefficient (Hietamo et al., 2020) was used to examine the relationships among BMI, body weight, and SHT performance, with significance set at $p < 0.05$. Objective, standardized SHT instructions and quantitative data analysis using SPSS version 29 provided a systematic framework to decrease subjective interpretation and ensure research reproducibility.

RESULTS

Descriptive Statistics: Mean height, weight, BMI, and SHT results are presented in Table 1. Normality testing in Table 2 confirmed suitability for parametric analysis.

Table 1. Descriptive Statistics For Patient Height(CM), Weight(Kg), Body Mass Index (kg/m2) and Single Hop Test Result(%)

	Mean (\bar{x})	Std. Deviation (SD)
Patient Height (CM)	166.94	7.208
Patient Weight (Kg)	63.537	8.8535
Patient Body Mass Index (Kg/m ²)	22.748	2.3848
Single Hop Test Result in Percentage (%)	94.34	2.414

Table 2. Tests of Normality for Patient Body Mass Index (Kg/m2), Patient Weight (Kg), and Single Hop Test (%)

	Kolmogorov-Smirnov ^a		Sig.	Shapiro-Wilk		Sig.
	Statistic	df		Statistic	df	
Patient Body Mass Index (Kg/m ²)	.162	116	<.001	.771	116	<.001
Patient Weight (Kg)	.210	116	<.001	.725	116	<.001
Single Hop Test Result in Percentage (%)	.143	116	<.001	.948	116	<.001

a. Lilliefors Significance Correction

The descriptive statistics indicate a performance range of 87% to 98% with a mean score of 94.34%, but do not include the raw distance values (e.g., in centimeters) for the contralateral limb across various demographic profiles. The study is predicated on the assumption that the uninjured limb serves as an internal control for limb symmetry, as evidenced by the findings of Vereijken et al. (2021); however, the author concludes that the principal predictors of the outcomes are physical-functional parameters compared to body weight alone.

The normality of the data distribution for variables such as BMI, patient weight, and SHT findings was evaluated using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The research revealed substantial departures from normality across all three variables, as evidenced by p-values below 0.001 for both statistical tests. Weight and BMI demonstrated significant positive skewness—3.211 and 2.755, respectively—indicating a distribution mostly centered on elevated values. The SHT results exhibited slight negative skewness (- 0.487), indicating a predominance of participants achieving elevated performance percentages. The researcher does not include an extensive table of normative reference values for the uninjured limb's hop distance; rather, the study predominantly reports the outcomes of the SHT as a percentage (%) of functional recovery. The literature review recognizes that the non-injured leg is an essential reference for assessing functional capabilities

instead of body weight, and it cites an LSI exceeding 90% as the criterion for return-to-sport clearance. However, the primary data emphasize the relationship between these percentages and anthropometric variables.

Relationship between BMI (Kg/m2) and Weight (Kg) with SHT Performance (%) is displayed in Table 3. A medium, statistically significant negative correlation was identified between BMI and SHT performance ($r = -0.188$, $p < 0.05$), in accordance with Cohen’s criteria for correlation strength. The correlation between body weight & SHT performance was of medium strength ($r = -0.121$) according to Cohen’s guidelines; however, this association was not statistically significant ($p > 0.05$). This suggests that although a mild linear trend was detected in the sample, it cannot be properly projected to the larger population.

Table 3: Pearson Correlations of BMI and Weight with Single Hop Test (SHT)

	Pearson Correlation (r)	Significance (2-tailed)	N
Patient Body Mass Index (Kg/m ²)	-0.188*	0.043	116
Patient Weight (Kg)	-0.121	0.196	116

*. Correlation is significant at the 0.05 level (2-tailed).

Key Observations: Higher BMI was associated with slightly lower hop performance, whereas absolute weight alone showed no significant relationship with performance.

The research revealed a minor, statistically significant negative association between BMI (Kg/m²) and SHT (%) performance ($r = -0.188$, $p = 0.043$). This indicates that increases in BMI correlate with slight reductions in functional outcomes, likely attributable to the detrimental impact of heightened body mass on dynamic balance and explosive force. However, the correlation between absolute body weight and SHT performance was determined to be statistically non-significant ($r = -0.121$, $p = 0.196$). The results suggest that body composition measurements, particularly BMI, are more significant predictors of functional recovery after ACL rehabilitation than absolute weight alone.

Despite the common requirement for nonparametric methods due to nonnormal data, the researcher concluded that the data were appropriate for parametric analysis and subsequently used Pearson's correlation coefficient to investigate the linear relationships between anthropometric variables and functional outcomes. Although the Shapiro-Wilk and Kolmogorov-Smirnov tests demonstrated significant deviations from normal distribution for BMI, body weight, and SHT performance, Pearson's correlation coefficient was employed as the principal analytical method due to the robustness of the sample size ($n=116$). According to the Central Limit Theorem, parametric evaluations like Pearson's (r) are deemed robust against non-normality in bigger samples, generally when ($n > 30$), as the sampling distribution approaches normality. Parametric evaluations are resilient to non-normality in bigger samples, according to the literature. Kwak and Kim state that "the means of a random sample of size n ... distribute normally" according to the CLT, which makes parametric statistical approaches more accurate with larger samples (Kwak & Kim, 2017). Melo et al. explain that as sample size increases, non-normality decreases, allowing parametric approaches to be used (Melo et al., 2024). This assertion is followed by a study by Cuyan-Zumaeta et al. (2025), stating that parametric tests, such as Pearson's correlation, are valid when sample sizes surpass 30 since the sampling distribution approaches normality.

Experimental evidence supports these claims. The CLT validated Tidmarsh et al.'s (2025) example of 211 sample sizes being large enough to yield strong ANOVA results despite non-normality. According to the CLT, Gomes et al. (2024) showed that parametric tests were justified even when normality was broken due to

sufficient sample sizes. Yao et al. also use the CLT to justify parametric testing in high-dimensional data situations (Leung & Drton, 2018).

The research purpose aimed to ascertain the strength and direction of a linear relationship between continuous anthropometric factors and functional recovery percentages. Pearson's (r) offers an accurate quantification of this linear relationship, crucial for formulating evidence-based protocols for physiotherapists to enhance rehabilitation results. Consequently, the claim that parametric evaluations, including Pearson's correlation coefficient, are resilient to non-normality in large samples is well supported by the literature on the CLT. Empirical evidence and theoretical discourse across various research consistently affirm this viewpoint, demonstrating the practical utility of parametric approaches despite underlying data non-normality. Plus, the extensive standardization in data collection, conducted by licensed physiotherapists with calibrated equipment, ensured data integrity, warranting a parametric approach to assess the correlation of these physical-functional indicators in a clinical context.

DISCUSSION

The descriptive statistics for Patient BMI and SHT outcomes clarify the fundamental tendencies and variability within the sample. The patients' average BMI is 22.748, with a standard deviation of 2.3848, indicating a consistent distribution around the mean and a reliable assessment within this patient group. The SHT results reveal a mean of 94.34% and a standard deviation of 2.414, indicating minimal variability in performance outcomes and affirming the reliability of the calculated mean percentage.

The correlation analyses between BMI and SHT results, as well as between Patient Weight and SHT outcomes, reveal weak negative associations. The Pearson correlation coefficient of -0.188 between BMI and SHT indicates a statistically significant, albeit weak, negative association ($p=0.043$), which is below the alpha level of 0.05. This suggests that a higher BMI is marginally associated with poorer SHT outcomes, with a modest correlation. An increased BMI is slightly correlated with inferior SHT outcomes, due to the impact of heightened body mass on balance and explosive strength. An increased BMI often leads to reduced lower-limb power output and impaired balance, both of which are critical for optimal performance in hop tests. Research indicates that increased BMI is associated with impaired balance, particularly in static postural stability evaluations across various age groups (Nagrle, 2020). On the other hand, the relationship between Patient Weight and SHT findings shows a Pearson correlation coefficient of -

0.121 and a p-value of 0.196. This indicates a weak negative correlation that is not statistically significant, as the p-value exceeds the conventional alpha level of 0.05. Therefore, we are unable to ascertain a definitive linear association between patient weight and SHT outcomes among the population represented by this sample. Body weight may not significantly affect the outcomes of SHTs, as several factors, including as balance and explosive strength, influence performance. This study indicates that while anthropometric parameters, such as weight, appear relevant, they do not show a significant correlation with hop test results.

BMI was modestly but significantly associated with SHT performance, whereas body weight was not. This suggests that body composition factors related to BMI may have a greater influence on functional performance than absolute weight. These results align with prior research indicating that BMI is a predictor of musculoskeletal injury risk and rehabilitation outcomes (Bojicic et al., 2017; Lestari et al., 2020; Hsu et al., 2018). While some studies show similar surgical outcomes across BMI categories (Kehribar & Coşkun, 2022), functional measures, such as the SHT, may still reveal subtle performance differences. The lack of association between body weight and SHT outcomes supports evidence that absolute mass is less important than proportional composition (Harput et al., 2018). SHT remains a valuable functional tool (Davies et al., 2019; Di Paolo et al., 2022; Dingenen et al., 2019), but results should be interpreted alongside anthropometric and contextual factors.

The SHT is a crucial element of return-to-sport (RTS) screening following ACLR and has been proven to be a highly reliable and sensitive instrument for evaluating functional recovery. The SHT is notably proficient at identifying limb asymmetries, with studies demonstrating that it, along with the triple hop for distance, outperforms other functional assessments at identifying individuals who do not meet the 90% Limb Symmetry Index (LSI) benchmark (Dingenen et al., 2019). Moreover, the SHT has exceptional test-retest reliability, with Intraclass Correlation Coefficients (ICCs) ranging from 0.93 to 0.98, highlighting its consistency as a clinical assessment (Millikan et al., 2019). In addition to immediate functional evaluation, the SHT serves as a vital prognostic marker, as successful completion of several functional tests, including hop evaluations, is strongly associated with lower reinjury rates and improved long-term outcomes (Ashigbi, Banzer, and Niederer, 2019). Thus, the SHT remains a justifiable and cost-effective gold standard for RTS protocols compared to more specialized and less accessible options. The SHT becomes valid as rehabilitation proceeds into the mid- to late postoperative period, especially started on 6th months

after surgery, when numerous patients start more dynamic activities (Wellsandt et al., 2017). As part of functional testing, patients should be strong enough to perform it without reinjury (Wellsandt et al., 2017; Grindem et al., 2016). It remains relevant until performance benchmarks are met, usually 12 months postoperatively. Also, by 12 months and beyond, players usually have knee function near to pre-injury levels, making the SHT a good tool for assessing return to sport (Mengis et al., 2025).

The efficacy of the SHT, an essential evaluation for assessing functional recovery post-ACLR, is influenced by multiple biomechanical parameters. In persons with excess weight or obesity, these biomechanical characteristics can substantially impact the efficacy and safety of motions like hopping, resulting in possible difficulties in recovery and heightened risk of re-injury. A key biomechanical metric influenced by overweight or obesity is ground reaction force (GRF). Research demonstrates that individuals with greater body mass frequently exhibit elevated ground reaction forces during jumping, resulting in increased stress on the knee joint, which may aggravate pre-existing joint issues (Wellsandt et al., 2017; Paterno et al., 2017). Increased GRF may arise from the greater mass that the lower extremities are required to sustain during the hop test. Such modifications can affect knee mechanics, resulting in compensatory motions or biomechanical overload during the landing phase (Dingenen & Gokeler, 2017). Increased GRF is associated with altered loading patterns that may trigger or accelerate degenerative changes in the joints, affecting recovery and long-term outcomes following ACLR (Paterno et al., 2017). Asymmetry in limb function poses a significant issue for overweight or obese persons following ACL reconstruction. Kotsifaki et al. highlighted that although hop distance symmetry may seem adequate, inherent biomechanical disparities between limbs might obscure major asymmetries and functional disadvantages, especially in individuals with excess weight (Kotsifaki et al., 2021). The relationship between body mass and limb asymmetry may lead to compensatory mechanisms that increase the likelihood of reinjury and hinder rehabilitation. Overweight individuals may exhibit altered knee joint angles, increased knee flexion, and inadequate hip and ankle mechanics. Kotsifaki et al. found that individuals with elevated body mass index (BMI) exhibit compromised knee flexion and extension moments, potentially impairing leaping ability and functional performance (Lepley & Kuenze, 2018). This biomechanical inefficiency in kinematics and kinetics may impair coordination and balance, thereby increasing the likelihood of faulty landings and resulting accidents.

Future research should explore additional confounding

variables such as age, gender, height, and limb strength, which may also influence SHT performance (Taniguchi et al., 2022; Welling et al., 2018; Keiner et al., 2024). Firstly, age greatly affects coordination and motor function. Although motor network connection changes, older persons complete sensorimotor tasks well, suggesting compensation mechanisms. Functional decoupling across motor cortex and control regions may impact hopping performance in elderly individuals (Yordanova et al., 2024). Neurocognitive loads do not affect lower limb coordination during hopping, suggesting age-related characteristics are more important (Reilly et al., 2023). Secondly, SHT performance is heavily influenced by gender, particularly knee biomechanics and injury susceptibility. Females have less leg and knee stiffness than males, which may increase the risk of unilateral ACL injuries (Zhang et al., 2023). Females had lower knee flexion angles and extension moments during unilateral workouts, which may affect stability and performance (Birchmeier et al., 2023). However, males exhibit larger peak hip abduction moments under certain conditions, suggesting distinct biomechanical responses (Taniguchi et al., 2022). Since hop tests may not accurately represent female risk characteristics, gender-specific diagnostics and rehabilitation strategies after ACL injuries are needed (Welling et al., 2018). Differences can affect SHT stability and performance. Thirdly, height may affect biomechanics & reactive strength index. Studies indicate that reductions in heights can significantly affect the reactive strength index, suggesting that a single height may not accurately reflect an individual's ability (Keiner et al., 2024). Jumping biomechanics, such as takeoff speed and location, may allow taller people to jump farther (Wood et al., 2025). Post-ACLR athletes often have leaping limitations that are not height-related. Kotsifaki et al. found that ACLR patients exhibit significant differences in jump height compared with healthy controls, regardless of limb length (2023). Next, SHT performance is also better correlated with muscle strength. According to Shi et al. (2022), poorer quadriceps strength on the repaired leg reduced knee extension moments during dynamic exercises, which are essential for jumping. Chaput et al. found that jump performance and quadriceps strength LSI predict functional outcomes in post-ACLR patients (Chaput et al., 2021). Unsymmetrical quadriceps strength resulted in functional losses on hop tests, highlighting the need for strength-focused rehabilitation (Ebert et al., 2017). Paterno et al. also noted that early and precise assessments of strength and hop performance reduce subsequent injuries (Paterno et al., 2017). Finally, there are psychological factors, particularly anxiety & fear. SHT among individuals with poor results have increased anxiety about the test. Legnani et al. (2023) found that higher ACL-RSI scores were associated with better vertical jump performance, suggesting that psychological factors can enhance physical

performance in ACL injury survivors. According to Sadeqi et al. (2018), psychological readiness, such as lesser fear and self-doubt, improves functional performance, including hop test outcomes. Plus, Nuno et al. found that psychological factors such as confidence and drive affect athletes' functional outcomes after ACLR, supporting the idea that athletes with greater psychological readiness perform better (Nuno et al., 2025).

It is also suggested that undetected chronic ailments or rehabilitation program adherence could skew results. Previous knee injuries and muscular disorders can hinder ACLR therapy. Kyritsis et al. (2016) found that not meeting essential discharge criteria—including strength and functional performance measures before RTS—increased the risk of graft rupture, suggesting that pre-existing conditions may affect ACL recovery and post-operative hopping ability. Such disorders can impede physical capacities and hamper functional recovery. Grindem et al. (2016) also found that athletes with pre-existing problems may experience delays in functional recovery, which can affect SHT performance. Compliance with a supervised rehabilitation program improves leaping ability and reduces re-injury (Phatomy & Setyawan, 2020). Poor compliance has been connected to inferior functional outcomes and an increased risk of comorbidities, which may contribute to poor hop test performance (Holling et al., 2022).

Research showed that participation in a comprehensive rehabilitation regimen incorporating weight management measures, with strength training, can alleviate the negative impacts of obesity on biomechanical performance. Interventions aimed at enhancing lower extremity strength, coordination, and control may improve landing mechanics and diminish the likelihood of re-injury (Zarro et al., 2021). Furthermore, the application of motion capture technologies and biomechanical evaluations in clinical settings may yield significant insights to enhance rehabilitation programs tailored to overweight or obese patients (Webster & Feller, 2018). While some studies suggest obese patients can achieve comparable surgical outcomes to those with normal BMI (Kehribar & Coşkun, 2022), others emphasize the need for further research on BMI's role in functional recovery (Harput et al., 2018).

CONCLUSION

A modest, statistically significant negative relationship was found between BMI and functional performance in the SHT after ACL sport rehabilitation, while body weight was not a significant predictor. These findings support integrating BMI control into rehabilitation planning to personalize protocols, optimise outcomes, and reduce reinjury risk.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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