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NEW ZEALAND

The Journal of Sport and Exercise Science, Vol. 5, Issue 1, 13-20 (2021)

www.sesnz.org.nz

JSES
ISSN: 2703-240X

Propensity for conscious control of movement is unrelated to asymptomatic hypermobility or injury-risk scores

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ARTICLE INFO

Received: 11.04.2020
Accepted: 12.08.2020
Online: 01.02.2021

Keywords:
Landing Error Scoring System
Movement Specific Reinvestment Scale
Movement screen
Asymptomatic hypermobility
Beighton Hypermobility Scale

ABSTRACT

The Movement Specific Reinvestment Scale (MSRS) measures the propensity for conscious monitoring and control of movement, which can inhibit automated movement processes, potentially causing movement disruption or injury. High injury risk individuals are more likely to make movement errors during jump-landing tasks, and hypermobile individuals present with poor movement control. The link between MSRS and these characteristics remains largely unexplored. Consequently, we examined propensity for movement specific reinvestment in high injury risk and asymptomatic hypermobile participants. Sixty volunteers (35 males, 25 females) were tested using the MSRS, Landing Error Scoring System (LESS), and Beighton hypermobility scale. Spearman rank correlation coefficients were computed between MSRS, LESS, and Beighton scores. Furthermore, MSRS scores were compared between low (LESS < 5 errors) and high (LESS ≥ 5 errors) injury risk, as well as non-hypermobile and hypermobile participants. MSRS scores were not significantly related to LESS ($\rho = 0.06$, $p = 0.625$) or Beighton ($\rho = 0.09$, $p = 0.481$) scores. MSRS scores of low and high injury risk (37.8 ± 7.8 vs 38.0 ± 8.6, $p = 0.933$), and non-hypermobile and hypermobile (37.5 ± 8.9 vs 39.0 ± 7.0, $p = 0.524$) participants were comparable. Based on our results, there is no evidence that movement specific reinvestment contributes to injury risk assessed by LESS, which might be due to the phylogenetic nature of the LESS jump-landing task and/or the low psychological pressure environment of laboratory testing. The propensity for movement specific reinvestment did not vary in asymptomatic hypermobile individuals compared to non-hypermobile individuals; however, examination of the MSRS in symptomatic hypermobile individuals and individuals with well-defined syndromes is needed to fully elucidate whether or not conscious monitoring and control of movement plays a role in injury risk or movement control across the hypermobility spectrum.

1. Introduction

It is well known that human movements are influenced by various psychological factors, such as fear of movement-related pain (Meulders, Vansteenwegen, & Vlaeyen, 2011), motivation (Kadosh & Staunton, 2019), or reinvestment (Masters, 1992; Masters & Maxwell, 2008). Reinvestment is defined as ‘manipulation of conscious, explicit, rule based knowledge, by working memory, to control the mechanics of one’s movements during motor output’ (Masters & Maxwell, 2004, p. 208). The Movement Specific Reinvestment Scale (MSRS) is a valid and reliable measure of the propensity for conscious involvement in movement (Masters, Eves, & Maxwell, 2005; Wong, Masters, Maxwell, & Abernethy, 2008). The MSRS consists of 10 statements about a person’s tendency to consciously process their movements or to be self-conscious about their style of movement (Table 1). Scoring of the MSRS statements is based on a Likert-type scale ranging from strongly agree (1 point) to strongly disagree (6 points). The maximum MSRS score is 60 points, with higher scores indicating greater propensity to consciously monitor and control movements. The theory of reinvestment proposes that consciously controlling and monitoring one’s own movements can constrain or inhibit more effective automatic control processes, which can potentially lead to movement disruption (Masters & Maxwell, 2008). High MSRS scores are associated with greater movement errors under psychological pressure in

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sport (Chell, Graydon, Crowley, & Child, 2003; Jackson, Ashford, & Norsworthy, 2006; Masters, Polman, & Hammond, 1993; Maxwell, Masters, & Poolton, 2006), slowed surgical performance by medical students under time pressure (Malhotra, Poolton, Wilson, Ngo, & Masters, 2012), higher fall incidence in older adults (Wong et al., 2008), more severe functional impairment after stroke (Orrell, Masters, & Eves, 2009), duration of Parkinson's disease (Masters, Pall, MacMahon, & Eves, 2007), and self-reported knee pain (Selfe et al., 2015).

The Landing Error Scoring System (LESS) is a reliable and valid injury risk screening tool that identifies movement patterns linked with non-contact injuries using a jump-landing task (Hanzlíková & Hébert-Losier, 2020). Clinicians evaluate frontal and sagittal plane videos from the LESS test and visually evaluate aberrant lower extremity and trunk kinematics from initial ground contact until maximal knee flexion. The LESS score consists of 17 items; movement items 1 to 15 are scored as 0 (error absent) or 1 (error present). The last two items (16 and 17) are subjective and assess the overall sagittal plane displacement and quality of landing. These two items are scored from 0 to 2 errors. The minimum (best) score is 0 and reflects the absence of movement errors, and the maximum (worst) score is 17 errors. Higher LESS scores indicate poorer jump-landing mechanics and greater risk of non-contact lower extremity injury. Padua et al. (2015) concluded that 5 errors was the optimal cut-off score for determining increased risk of non-contact Anterior Cruciate Ligament (ACL) injury incidence. The risk ratio for sustaining a non-contact ACL injury when LESS scores were 5 errors or greater (compared to lower than 5 errors) was 10.7 (Padua et al., 2015). A previous study concluded that elder fallers scored significantly higher on the MSRS compared to non-fallers (Wong et al., 2008). The authors argued that the high propensity to reinvest might contribute to cautious gait in those with fear of falling, which disrupts automaticity of walking and increases risk of falling and associated injury risk (Wong et al., 2008). Therefore, it is possible that athletes who consciously monitor their own movements may exhibit a greater number of landing errors during LESS assessment and be at greater risk of sport-related injuries.

Generalized hypermobility is an identified risk factor for injury (Dallinga, Benjaminse, & Lemmink, 2012; Donaldson, 2012; Pacey, Nicholson, Adams, Munn, & Munns, 2010), including the ACL injury (Goshima, Kitaoka, Nakase, & Tsuchiya, 2014; Sundemo et al., 2019). Generalized joint hypermobility is usually a congenital inherited disorder of connective tissue characterized by increased movement in multiple joints beyond normal physiological ranges expected in a given population (Castori et al., 2017; Malfait et al., 2017). Overall, the prevalence of generalized hypermobility reported to exist in the general population is between 10 to 20% (Remvig, Jensen, & Ward, 2007b). Generalized joint hypermobility can be categorized as individuals with asymptomatic joint hypermobility, individuals with well-defined syndrome associated with joint hypermobility, and individuals with symptomatic joint hypermobility (Castori et al., 2017). Besides a range of musculoskeletal symptoms (Hakim & Grahame, 2003), generalized hypermobility has been associated with a greater prevalence of panic disorder and anxiety (Garcia-Campayo, Asso, & Alda, 2011), attention-deficit and hyperactivity disorder (Baeza-Velasco, Sinibaldi, & Castori, 2018), fatigue (Krahe, Adams, & Nicholson, 2018), and pain hypersensitivity (Bettini, Moore, Wang, Hinds, & Finkel, 2018). Given that the propensity for movement specific reinvestment has also been linked to fear, anxiety, fatigue, and movement difficulties and disorders, there may be an association between hypermobility and conscious engagement in movement. Conscious engagement in movement may therefore be contributing to the altered movement patterns (Fatoye, Palmer, Van der Linden, Rowe, & Macmillan, 2011; Galli et al., 2011; Luder et al., 2015; Simonsen et al., 2012) and increased injury risk (Pacey et al., 2010) in hypermobile individuals.

The association between propensity for movement specific reinvestment, biomechanical control, and hypermobility has not been studied to date. The propensity for movement specific reinvestment may be an important injury risk factor to consider that may assist injury prevention efforts via the development and implementation of more targeted, multi-modal interventions for these individuals. Participants with symptomatic generalized joint hypermobility or well-defined syndromes associated with hypermobility often present with chronic pain and fatigue to various extents, which may influence the results. Several physically active individuals present with asymptomatic generalized joint hypermobility (Luder et al., 2015) and are clinically perceived at a higher risk of injury given their hypermobile status, although limited research has focused on this population specifically. Therefore, the aim of this paper was to explore the relationship between MSRS, LESS, and Beighton scores in young active asymptomatic individuals, as well as to compare MSRS scores between participants at low and high injury risk, as well as between non-hypermobile and asymptomatic generalized hypermobile participants. We hypothesized that participants at high injury risk and those presenting with asymptomatic generalized hypermobility would exhibit greater MSRS scores than low injury risk and non-hypermobile participants, respectively.

Table 1: The Movement Specific Reinvestment Scale. Adapted from Masters et al. (2005).

Conscious Motor Processing items
I remember the times when my movements have failed me.
I reflect about my movement a lot.
I try to think about my movements when I carry them out.
I am aware of the way my body works when I am carrying out a movement.
I try to figure out why my actions failed.
Movement Self-Consciousness items
If I see my reflection in a shop window, I will examine my movements.
I am self-conscious about the way I look when I am moving.
I sometimes have the feeling that I am watching myself move.
I am concerned about my style of moving.
I am concerned about what people think about me when I am moving.

2. Methods

2.1. Participants

Given that no published data exist regarding the association between MSRS, LESS, and Beighton scores, we calculated sample size requirements based on the ability to detect a correlation of moderate magnitude (i.e., 0.50) (Mukaka, 2012). Based on sample size calculations using a customizable statistical spreadsheet (Hopkins, 2006) from standard two-tailed hypothesis equations using an 90% power (β = 0.10) and 5% significance level (α = 0.05), we needed at least 38 participants to detect a moderate correlation between measures. Given that 60 individuals agreed to participate, our study sample size is powered to detect a correlation of 0.40 in magnitude.

To be included, participants needed to be involved in sport activity; and be free from injury, pain, or any other issue that would limit physical activity at the time of study participation. Previous injuries were not an exclusion criterion. This study aimed to assess only non-hypermobile and asymptomatic hypermobile participants according to the framework for the classification of joint hypermobility proposed by Castori et al. (2017). Therefore, participants with chronic pain or known diagnosis of medical syndromes associated with joint hypermobility (e.g., Ehlers Danlos and Marfan syndrome) were excluded. Sixty young adults (35 males, 25 females) fulfilled the inclusion criteria and participated in this study. Age, height, and mass (mean ± standard deviation) for males were 23.2 ± 4.7 years, 181.2 ± 6.6 cm, and 83.9 ± 3.2 kg; and 22.2 ± 5.6 years, 169.3 ± 5.8 cm, and 66.2 ± 2.6 kg for females. Participants were involved in organized sport activity 3 times per week (median), on average for 6.4 ± 4.4 hours a week. The study protocol was approved by our institution's Health Research Ethics Committee [HREC(Health)#2018-27] and adhered to the Declaration of Helsinki. All participants signed a written informed consent document that explained the potential risks associated with testing before participating. Note that participants were not screened for generalized joint hypermobility prior to participation.

2.2. Procedure

All tests were completed in a single session. After self-administered MSRS completion, half of the participants completed the LESS protocol followed by the Beighton diagnostic test for hypermobility, whereas the other half completed the tests in the reverse order. The MSRS has adequate internal reliability (coefficient alpha = 0.80), teste-retest reliability (Pearson product moment correlation coefficient = 0.74), and validity (Masters et al., 2005; Masters et al., 1993). The LESS has been validated against 3D motion capture and has good-to-excellent intrarater [intraclass correlation coefficient (ICC), 0.82-0.99], interrater (ICC, 0.83-0.92), and intersession (ICC, 0.81) reliability reported in the scientific literature (Hanzlíková & Hébert-Losier, 2020). The Beighton score is a major criterion used in diagnosing joint hypermobility syndrome, and is a valid and reliable (kappa = 0.75 to 0.78) diagnostic tool for joint hypermobility (Remvig, Jensen, & Ward, 2007a). In this study, sex and age-specific cut-off scores based on Singh et al. (2017) were used to categorize hypermobility. Specifically, the cut-off score for hypermobility of ≥ 5 points was used for females, and ≥ 4 for males in our sample.

The LESS testing procedure used here was identical to the procedure described elsewhere (Padua et al., 2009). Participants jumped horizontally from a 30-cm high box to a line placed at 50% of their body height, and immediately jumped upward for maximal vertical height. Participants were instructed to jump off the box with both feet, land in front of the designated line, and jump as high as possible upward upon landing. We provided no feedback on landing technique unless participants were performing the task incorrectly. Participants were given as many practice trials as needed to become comfortable with the task (typically one). Each participant performed three trials of the double-leg jump-landing task in their own footwear. To mitigate effects of fatigue, participants were allowed to rest until they felt ready to perform the second and third trial of the task. Two tripod-mounted digital cameras (Sony RX10 II, Sony Corporation, Tokyo, Japan) with an actual focal length of 8.8 to 73.3 mm (35-mm equivalent focal length of 24-200 mm) captured performance of the task at 60 Hz. The cameras were placed 3.5 m in front of and to the right side of the landing area with a lens-to-floor distance of 1.3 m to capture frontal and sagittal plane motion. One investigator (IH) with experience of over 400 LESS evaluations replayed the videos using the open-source Kinovea video analysis software (version 0.8.15, www.kinovea.org). The investigator scored the first landing of the jump-landing task of all three trials (i.e., when landing from the box) using the 17-item LESS scoring criteria (Padua et al., 2009). The investigator was blinded to the MSRS and Beighton hypermobility scores.

An experienced physiotherapist (IH) recorded the Beighton scores, consisting of five components: (1) passive dorsiflexion and hyperextension of the fifth metacarpal joints (little fingers) beyond 90°, (2) passive apposition of the thumbs to the flexor aspects of the forearms, (3) passive hyperextension of the elbows beyond 10°, (4) passive hyperextension of the knees beyond 10°, and (5) active forward flexion of the trunk with the knees fully extended so that the palms of the hands rest flat on the floor (Beighton, Solomon, & Soskolne, 1973), following standard protocols and using a hand-held goniometer (Smits-Engelsman, Klerks, & Kirby, 2011). Note here that the first four elements can be given a maximum score of 2 points because these are performed bilaterally (i.e., 1 point for each hypermobile joint), whereas the last element has a maximum score of 1 point. Hence, a total score of 9 points is possible.

2.3. Statistical approach

Mean ± standard deviation, median (interquartile range), and range (minimum to maximum) values were calculated to describe variables based on variable type. Note that the mean LESS score from the three trials completed by each participant was used for statistical analysis. Statistical significance level was set at $\alpha \leq 0.05$ for all analyses. The statistics were computed using Microsoft® Excel® for Office 365 MSO and RStudio® Version 1.1.463 with R version 3.5.2.

To investigate the relationship between MSRS, LESS, and Beighton scores, Spearman rank correlation coefficients (ρ) were calculated given the ordinal nature of the data. The correlation coefficient values were interpreted using thresholds of 0.30, 0.50, 0.70, and 0.90 to indicate low, moderate, high, and very high correlations (Mukaka, 2012). Correlations below 0.30 were considered negligible.

Independent *t*-tests with equal variance were conducted to investigate differences in MSRS scores between low and high (LESS ≥ 5 errors) injury risk, and non-hypermobile and hypermobile (Beighton score ≥ 5 points for females and ≥ 4 points for males) participants. Mean differences and 95% confidence intervals [upper, lower] in MSRS scores between groups and corresponding effect sizes (Hedge's *g*) with 95% confidence intervals were calculated. Thresholds for interpreting the magnitude of Hedge's *g* were 0.20, 0.50, and 0.80 for small, medium, and large effects (Lakens, 2013). Effect sizes below 0.20 were considered trivial. There were no missing data, so data from all 60 participants were analyzed. Note that analysis of each MSRS subscale (Conscious Motor Processing and Movement Self-Consciousness) separately yielded similar results.

3. Results

The mean MSRS score for all participants was 37.9 ± 8.3 points (range: 19 to 54). Mean LESS score was 5.3 ± 1.5 errors (range: 2.0 to 9.7). The median and interquartile range of Beighton score for all participants was 2.5 (4.0) points (range: 0 to 9).

There was a negligible non-significant relationship between MSRS and LESS scores ($\rho = 0.06$, $p = 0.625$) and MSRS and Beighton scores ($\rho = 0.09$, $p = 0.481$). The MSRS scores between participants at low and high injury risk were similar (Table 2). There was no significant difference in MSRS scores between non-hypermobile and hypermobile participants, with a trivial effect of grouping on MSRS scores (Table 2).

4. Discussion

The purpose of our study was to investigate the relationship between MSRS, LESS, and Beighton scores, and to compare MSRS scores between high and low injury risk participants and between non-hypermobile and asymptomatic hypermobile participants. In our cohort, there was no significant relationship between MSRS, LESS, and Beighton scores, and no difference in MSRS scores between the subgroups analyzed. The results indicate that participants with greater propensity for conscious monitoring and control of their movements do not present with a greater number of high injury risk movement patterns during double-leg jump-landing as assessed by the LESS and propensity for movement specific reinvestment does not vary in asymptomatic hypermobile individuals compared to non-hypermobile individuals.

The lack of an association between injury risk according to LESS scores and movement specific reinvestment could be due to the phylogenetic nature of the LESS task, the manner in which reinvestment occurs, the low-pressure testing environment, or a combination of these factors. Unlike ontogenetic skills, which require people to learn them, phylogenetic skills (such as jumping) typically can be performed by anyone who is healthy, with minimal conscious processing (Masters & Poolton, 2012). Consequently, phylogenetic skills tend to be less susceptible to disruption by conscious control (reinvestment) than ontogenetic tasks (Masters & Poolton, 2012), which would mitigate differences between high and low MSRS scores. Previous studies have also confirmed an association between high propensity for movement specific reinvestment and poorer sport-specific task performance under psychological pressure (Chell et al., 2003; Jackson et al., 2006; Maxwell et al., 2006). Specifically, individuals with high MSRS scores displayed greater susceptibility to skill failure during soccer kicking (Chell et al., 2003), golf putting (Maxwell et al., 2006), and field-hockey dribbling (Jackson et al., 2006) under high pressure situations. These ontogenetic skills are seldom automated to the same extent as phylogenetic skills, so they require considerable concentration to be performed correctly and their execution is easily processed consciously. Psychological pressure amplifies the likelihood that performers (especially high reinventors) will process their movements consciously to ensure that their performance remains effective, but often this 'overthinking of movement' can disrupt fluid movement (Baumeister, 1984; Beilock & Carr, 2001; Gray, 2004; Masters, 1992). The double-leg jump-landing task tested by the LESS requires participants to jump horizontally from a 30-cm high box to a line placed at 50% of their body height, and immediately jump upward as high as possible upon landing. The

Table 2: Comparison of MSRS scores between groups in the sampled cohort (*n* = 60).

	n	MSRS scores (points)	MD [95% CI]	*t*-test	Hedge's *g* [95% CI]
At low risk [a]	21	37.8 ± 7.8	-0.2	0.933	-0.02
At high risk [a]	39	38.0 ± 8.6	[-4.7 to 4.3]		[-0.56 to 0.51]
Non-hypermobile [b]	41	37.5 ± 8.9	-1.5	0.524	-0.18
Hypermobile [b]	19	39.0 ± 7.0	[-6.1 to 3.2]		[-0.72 to 0.37]

Abbreviations: *n*, number of participants; MSRS, Movement Specific Reinvestment Scale; MD, mean difference; CI, confidence interval.
[a] At low risk Landing Error Scoring System (LESS) scores < 5 errors; at high risk LESS scores ≥ 5
[b] Hypermobile, Beighton score ≥ 5 points for females and ≥ 4 points for males; non-hypermobile, Beighton score < 5 points for females and < 4 point for males.

task involves movements that are presumably highly automated, so it requires minimal concentration and cannot easily be processed consciously. Thus, performance of the task is less likely to be influenced by movement specific reinvestment. Furthermore, the LESS testing environment imposes minimal pressure to perform well. Participants are not informed of the LESS scoring criteria when they perform the test and receive no performance feedback that might reveal innate movement patterns linked with a higher risk of sustaining non-contact lower-body and ACL injuries. As such, participants therefore are unaware of what characterizes good LESS performance or whether they are performing well (or not). Results might have been different with presence of an overhead target given that it can act as an external motivator and performance indicator, thereby altering movement patterns (Ford et al., 2005; Ford, Nguyen, Hegedus, & Taylor, 2017). Injury-risk and propensity for conscious monitoring and control of movement may be related under certain circumstances, with the association only surfacing in cases where participants are highly motivated to perform successfully (e.g., under pressure) or when they are aware of what constitutes successful or unsuccessful performance. Future research should examine this possibility by testing biomechanics during demanding high-injury risk sport-specific tasks under psychological pressure similar to the competition environment. Only once such investigations are completed will it be possible to reach conclusions about the potential role of movement specific reinvestment in sport-related injuries.

The theory of reinvestment proposes that, in addition to psychological pressure, a variety of other contingencies can cause a person to direct attention to conscious movement processing. These include instructions, novel task demands, boredom, and performance errors (Masters & Maxwell, 2008). For the purposes of LESS task standardization, participants received several instructions during testing. The instructions were to jump off the box with both feet, land in front of the designated line, and jump as high as possible upward upon landing (Padua et al., 2009). However, these instructions are unlikely to cause participants to direct their attention towards the mechanics of their movements; indeed, the instruction to jump upward for maximal vertical height is important in LESS testing because it shifts participants' focus towards performance rather than landing mechanics (Padua et al., 2009). Consequently, focusing externally on movement outcomes, in this case on the height of the jump, rather than internally on the movements is likely to have distracted attention away from the movement biomechanics, thereby reducing the likelihood of movement specific reinvestment (Maxwell et al., 2006; Wulf, Weigelt, Poulter, & McNevin, 2003).

With progressing age, degenerative changes affect all body systems and often result in pain, fatigue, muscle weakness, sensory deficits, poor balance, cognitive deficit, and other comorbidities, which are common in the elderly population (Schultz, 1992). All of these signs and symptoms impair mobility and make every movement challenging (Schultz, 1992). It may be that elderly people with movement impairment consciously process movement to avoid pain, falls, or trauma. Increased reinvestment may lead to disturbed movement patterns and greater injury risk compared to low reinvestors, similar to elder fallers who scored significantly higher than non-fallers on the MSRS (Wong et al., 2008). Therefore, it is possible that an association between MSRS scores and injury risk exists and should be further explored in the older population. Furthermore, severity of movement impairment may be positively associated with MSRS scores given that propensity for reinvestment has been shown to be greater in people with stroke compared to age-matched controls (Orrell et al., 2009), and to be positively associated with duration of Parkinson's disease (Masters et al., 2007). Disorder of connective tissue and excessive joint movement increase the likelihood of macro and micro traumas to the musculoskeletal system, which in turn lead to acute and persistent pain, early joint osteoarthrosis, and loss of function in hypermobile individuals (Castori et al., 2017; Tinkle et al., 2017). For instance, hypermobile individuals present with a higher degree of joint osteoarthrosis earlier in life compared to non-hypermobile peers (Tinkle et al., 2017). Therefore, the hypermobile population may present with greater movement impairment and associated pain earlier in life, which may lead to greater conscious processing of movements compared to non-hypermobile age-matched individuals. However, there is no supporting evidence currently available to support or refute that elder hypermobile individuals consciously process movements to a greater extent compared to age-matched non-hypermobile individuals.

The asymptomatic hypermobile participants tested in our study did not exhibit higher MSRS scores compared to non-hypermobile participants. The framework for the classification of joint hypermobility (Castori et al., 2017) used in our study suggests categorising hypermobile individuals as (1) those with asymptomatic joint hypermobility, (2) those with a well-defined syndrome associated with joint hypermobility (e.g., Ehlers Danlos syndrome and Marfan syndrome), and (3) those with symptomatic joint hypermobility. Studies exploring injury risk and anxiety in hypermobile individuals have not differentiated between joint hypermobility groups according to this classification (Dallinga et al., 2012; Donaldson, 2012; Pacey et al., 2010), with most previous studies exploring movement of hypermobile individuals involving children (Fatoye et al., 2011; Junge et al., 2015), symptomatic individuals (Simonsen et al., 2012), or individuals with well-defined disorders (Galli et al., 2011; Rombaut et al., 2011). Based on our knowledge, a single study has involved asymptomatic hypermobile individuals (Luder et al., 2015). In this study, symptomatic hypermobile females showed significantly lower EMG activity for the quadriceps during stair climbing compared to females with normal mobility; however, the EMG activity of asymptomatic hypermobile females did not differ from controls. These results indicate that there may be some clinically relevant differences in neuromuscular control and muscle recruitment patterns between asymptomatic and symptomatic hypermobile individuals that require further exploration. It is possible that our sample of asymptomatic hypermobile individuals adapt to their condition and use strategies to actively stabilize their hypermobile joints during dynamic tasks, which may explain to some extent why they do not suffer from chronic pain and other symptoms typically associated with hypermobility. Therefore, it may be that the asymptomatic hypermobile individuals tested in our study presented with similar injury risk, prevalence for anxiety, and movement control compared to our non-hypermobile individuals, which would explain the lack of significant differences between hypermobile and non-hypermobile participants in terms of MSRS scores. Furthermore, symptoms associated with symptomatic hypermobility (e.g., chronic pain or fatigue) potentially play a more important role in injury risk and be more strongly associated with MSRS scores compared to hypermobility itself. Therefore, we recommend that future research explores the MSRS in symptomatic hypermobile individuals and individuals with well-defined syndromes associated with joint hypermobility to fully elucidate whether or not conscious monitoring and control of movement plays a role in injury risk or movement control of hypermobile individuals.

Based on our results, propensity for movement specific reinvestment was not significantly associated with injury risk assessed by the LESS, which may be due to the phylogenetic nature of the LESS task and the low-pressure testing environment. Examining the influence of reinvestment on the biomechanics of demanding sport and injury specific tasks under psychological pressure similar to a competition environment is needed to determine whether reinvestment-specific interventions may assist injury prevention efforts. Participants with asymptomatic generalized hypermobility did not present with significantly different MSRS scores compared to non-hypermobile participants. Examination of the MSRS in symptomatic hypermobile individuals and individuals with well-defined syndromes is needed to elucidate whether or not conscious monitoring and control of movement plays a role in these conditions. This information would inform clinical practice and whether implementing motor learning strategies that discourage the propensity for reinvestment is of potential benefit during the rehabilitation process in these population groups.

Conflict of Interest

The authors declare no conflict of interests.

Acknowledgment

No acknowledgement.

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