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Original Research Article

DOES MCCONNELL TAPING OR THE STABILITY THROUGH EXTERNAL ROTATION OF THE FEMUR (SERF) STRAP AFFECT REARFOOT PLANTAR LOADING PATTERNS DURING WALKING IN HEALTHY ADULTS?

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ABSTRACT

Background: Changes in patellofemoral joint biomechanics have the potential to influence function of the lower extremity. McConnell taping has been proposed to reduce pain in individuals with patellofemoral pain syndrome (PFPS). It is also believed to improve vastus medialis oblique (VMO) muscle, patellofemoral alignment, and stride length. The stability through external rotation of the femur (SERF) strap has been developed to pull the femur externally to stabilise the patellofemoral joint, in order to reduce patellofemoral pain and improve lower limb kinematics. A lack of literature has examined effects of these two treatment methods on plantar pressures. Therefore, the aim of this study was to investigate the effects of McConnell taping and the SERF strap on rearfoot plantar loading patterns during walking in healthy adults.

Materials and Methods: Twenty-three participants (12 males and 11 females, age: 26.52±6.4 years) were randomly tested under 3 conditions: 1) no tape, 2) McConnell taping, and 3) SERF strap. Each participant was instructed to walk on a 2 m pressure plate at their own natural pace. Three valid stance phases of the right foot were recorded for each condition. Maximum pressures of medial heel and lateral heel, contact area of medial heel and lateral heel, initial heel contact, foot axis angle, and centre of pressure were collected.

Results: There were significant differences of maximum pressures of lateral heel (p = 0.011) with McConnell taping condition and the SERF strap condition demonstrating higher pressures than the no-tape condition (p = 0.042, p = 0.010 respectively). However, significant differences of other variables were not found.

Conclusion: The differences of maximum pressures of lateral heel between the conditions could be a clinical role for McConnell taping or SERF strap use in reducing rearfoot pronation in individuals with lower extremity problems especially PFPS.

KEY WORDS: Patellofemoral pain syndrome, Plantar pressure, Foot pronation, Medial patellar taping, SERF strap

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INTRODUCTION

Changes in patellofemoral joint biomechanics have the potential to influence function of the lower extremity. Medial patellar taping is an inexpensive treatment option that has been proposed to immediately reduce pain following application in individuals with patellofemoral pain syndrome (PFPS) [1-3] . Patellar taping has become widely used since the introduction of the original approach by Jenny McConnell in

1984 [4]. It is believed that the reduction of pain following the medial tape application is associated with alterations in patellofemoral joint reaction forces [1]. In addition to pain reduction, medial patellar taping has also been proposed to improve the activity of vastus medialis oblique (VMO) and facilitating strengthening exercises of quadriceps femoris muscle [5-8]. Patellofemoral alignment [9-11] and stride length [12] during ramp ascent have also been shown to be improved after medial taping application. However, there is a lack of literature examining the effects of medial patellar taping on plantar pressures during walking.

Excessive and/or prolonged rearfoot pronation has been shown to lead to excessive medial rotation of the tibia and the femur in a closed kinetic chain [13]. When the femur rotates medially, the compression between the lateral side of the patella and the femur increases, resulting in increased patellofemoral joint stress [13-18]. The forces on the knee during weight-bearing activities are transmitted from the foot to the knee. Hence, loading of the knee and patellofemoral joint can be influenced by force and loading patterns at the foot [17]. By correcting excessive rearfoot pronation, external tibial rotation is increased, eliciting a relative medial patellar glide [19]. Higher loading on the medial areas of the plantar surface of the foot during running and other weight-bearing activities have been suggested to be important factors for lower limb injuries [14, 17]. Willems et al. (2006) [20] and Willems et al. (2007) [21] found increased pronation, accompanied with more pressure on the medial side of the rearfoot in healthy people who developed exercise-related lower leg pain during barefoot running. These findings are interesting because a greater medial foot-loading pattern may increase lateral force on the patellofemoral joint.

The Stability through External Rotation of the Femur ®(SERF) strap (Don Joy Orthopedics Inc, Vista, CA) has been developed to pull the femur into external rotation to stabilise the patellofemoral joint, in order to reduce patellofemoral pain and improve lower limb kinematics during dynamic activities [22-24]. Since it has been suggested that abnormal patellar tracking may be the result of excessive internal rotation of the femur and tibia from excessive rearfoot pronation, it is proposed that the application of the SERF strap should alter plantar loading patterns by pulling the femur laterally resulting in a reduction in medial tibial rotation and foot pronation. Although McConnell taping has become very popular for patellofemoral pain management, relatively little is known regarding its effect on rearfoot pressures [19]. Therefore, the aims of this study were to investigate the effects of both McConnell taping and the SERF strap on rearfoot plantar loading patterns during walking in healthy adults. On the basis of the review and the evidence that is presented, the McConnell taping has been associated with changing of patellofemoral joint reaction force and the SERF strap has been developed to pull the femur laterally so the hypotheses of this study were that both McConnell taping and the SERF strap would alter rearfoot plantar loading patterns during walking.

METHODOLOGY

Participants and study design: The sample size was calculated using G*Power 3.1.9.2 [25] with ANOVA repeated measures, within factors at the power of 0.85, medium effect size (0.3), and a 0.05 alpha level. A minimum sample size was 22 but 23 participants (12 males and 11 females) were recruited in this cross-sectional study. The average age of the participants was 26.5±6.4 years with an average weight of 69.7±14.8 kg and an average height of 171.7±8.9 cm. All participants were healthy individuals aged between 18 and 35 years who had engaged in physical activities for 2 hours or more per week during the previous 12 months before the beginning of the study with no discrepancy of 1 cm or greater in lower leg length [26] and normal arch of foot measured by using the plantar arch index (A/B) [27]. Participants had no history of surgery or injury involving the lower leg, ankle or foot in the last 12 and 6 months respectively [20] and no knee pain with activity [28].

Procedures: All participants were randomly tested in a walking activity under 3 conditions: 1) no tape, 2) McConnell taping, and 3) SERF strap. Starting with the participants lying on their back, a rolled-up towel was placed under the

right knee. Before the tape application, the participant's knee were shaved using a razor. During the tape application, an approximately 15 cm length of hypoallergenic tape (5 cm wide) was first applied on the knee with no tension to avoid allergic reactions [29]. A 10 cm length of zinc oxide tape (3.8 cm wide) as commonly used for McConnell taping was placed over the hypoallergenic tape on the lateral patellar border and the other end of the tape was medially pulled over the patella and secured near the medial femoral condyle [19]. Wrinkles of the skin at the inner aspect of the knee (Figure 1) were used as an indication that the patella had been moved medially. In the SERF strap condition, the SERF strap was applied on the right leg while the participants sat on a chair. The strap was wrapped around the lower limb from the knee to the waist (Figure 2). The tensioning of the strap and the direction of pull was to facilitate lateral rotation of the femur.

The participants gave written informed consent and the study was approved by School of Sport and Exercise Sciences Research Ethics and Advisory Groups (SSES REAG), University of Kent at Medway (Ethics reference: 143-2014_2015). Data were collected using a 2 m footscan pressure plate (RSscan International, Belgium). Before the testing started, all participants were acquainted with the data collection procedures including walking on the pressure plate (5-6 trials with no tape) until they felt comfortable [30]. During the study, each participant was instructed to walk on the pressure plate at their own natural pace while looking straight ahead and not towards the floor [15]. The participants were asked to start walking with their left foot first so that a completed right foot step was recorded. The participants performed all tests barefoot. The condition order (no tape, McConnell taping, and SERF strap) was assigned randomly between participants to control potential order effects. Three valid stance phases of the right foot were recorded for each condition. A trial was considered valid when the entire right foot was captured. Participants were given 3 minutes to recover between each of the conditions [22].

Statistical analysis: All rear foot plantar loading patterns were expressed as mean±standard deviation (SD). Maximum foot pressures of medial heel (MH) and lateral heel (LH) were normalised by the participants' body weight. The data were checked for normal distributions using Shapiro-Wilk test. Maximum pressures of MH and LH and initial heel contact were not normally distributed so they were analysed by Friedman test and Wilcoxon Signed Rank test. Contact area of MH and LH, foot axis angle, and centre of pressure (COP) were analysed by repeated measures ANOVA and Tukey's Post-Hoc test as the data were normally distributed. The data were analysed using SPSS 16.0 (Norusis/SPSS Inc., Chicago, IL, USA).

Fig. 1: Application of McConnell taping (medial patellar taping) on the right knee

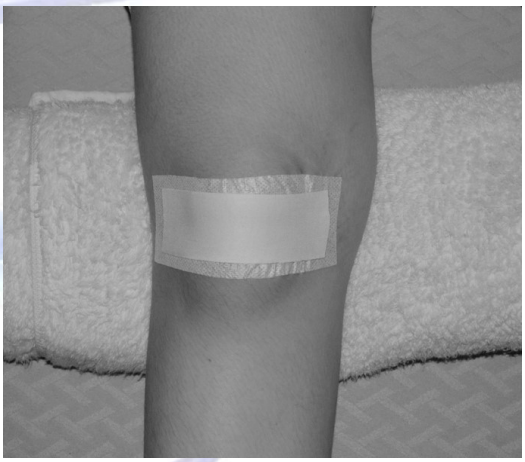

Fig. 2: Application of the stability through external rotation of the femur (SERF) strap on the right knee.

RESULTS

Twenty-three participants' foot pressures (12 men and 11 women) were collected in this study. There were statistically significant differences of maximum pressures of LH (p = 0.019) with McConnell taping condition demonstrating

higher maximum LH pressure than the no-tape condition (p = 0.042) and the SERF strap condition demonstrating higher maximum LH pressure than the no-tape condition (p = 0.010). However, significant differences of maximum pressures of MH, contact area of MH and LH, initial heel contact, foot axis angle, and COP were not found between the treatment conditions (Table 1).

Table 1: Mean differences of maximum pressures of MH and LH, contact area of MH and LH, initial heel contact, foot axis angle, and COP during walking.

Walking (n = 23)	No tape	McConnell	SERF	p-value
Maximum pressure of MH ($N/cm^2/kg$)	0.113±0.03	0.114±0.04	0.121±0.06	0.068
Maximum pressure of LH ($N/cm^2/kg$)	0.105±0.03	0.112±0.05*	0.113±0.05*	0.019**
Contact area of MH (cm^2)	16.74±2.69	16.57±2.79	16.66±2.82	0.422
Contact area of LH (cm^2)	14.84±2.31	14.63±2.49	14.77±2.45	0.273
Initial heel contact (ms)	59.45±14.95	58.42±13.66	60.48±15.42	0.486
Foot axis angle (degree)	12.69±8.57	11.77±8.55	12.06±8.50	0.216
Center of pressure (mm)	-1.00±2.21	-0.95±2.60	-1.36±1.97	0.146

** Friedman test $p \leq 0.05$ * Wilcoxon signed rank test $p \leq 0.05$ (compared to No tape)

DISCUSSION

This study is the first to evaluate the effects of McConnell taping and SERF strap on rearfoot plantar loading patterns during walking. The main findings of this study were that there were significant differences of maximum pressures of LH between the no-tape condition and McConnell taping (p = 0.042) and between the no-tape condition and the SERF strap condition (p = 0.010). These findings result in the acceptance of the hypothesis that both McConnell taping and the SERF strap have significant effects on rearfoot plantar loading patterns during walking.

McConnell taping is believed to unload abnormally stressed soft tissue around the patellofemoral joint, to improve patellar alignment, and to improve lower limb mechanics including the foot [29]. In the present study, the application of McConnell taping increased maximum pressures of LH during walking. The results are in line with Nyland et al. (2002) [19] who found significant differences on anterior-posterior peak plantar force location of the forefoot and peak plantar force onset with the participants displaying a more forefoot directed peak plantar force location and delaying peak plantar force onset following initial ground contact when applying McConnell taping on basketball players while running and dribbling a basketball before the lay-up. The results of this study suggest that McConnell taping has an effect on distal lower extremity function by shifting peak planter force anteriorly towards the forefoot and delaying peak plantar force onset.

The SERF strap has been used to assist lower limb kinematics and support femoral abduction and external rotation. In the present study, maximum pressure of LH while wearing the SERF strap was significantly higher than maximum pressure of LH with the no-tape condition during walking. A possible reason is that the SERF strap could be pulling the femur and the tibia laterally and, in so doing, reducing pronation of the foot and increasing the lateral loading of the rearfoot. The demonstration that the SERF strap changes plantar loading patterns in healthy participants supports the need for future studies to evaluate the effect of the SERF strap on plantar pressure in people with PFPS.

Significant differences of MH maximum pressures between the 3 conditions were not found in the study. However, the SERF strap did display higher MH maximum pressure than the McConnell taping, although this was not significant. A larger sample size may have resulted in a significant difference in MH maximum pressures between the 3 conditions.

Excessive rearfoot pronation is frequently associated with PFPS development [31] so individuals with PFPS present with larger contact areas at the medial rearfoot [14, 28]. From the results of the present study, both McConnell taping and SERF strap tended to reduce contact areas of the medial rearfoot during walking (no tape: 16.74±2.69 cm^2, McConnell taping: 16.57±2.79 cm^2, SERF strap: 16.66±2.82 cm^2, p = 0.422). Although these differences were not statistically significant, a Type II error may have occurred due to the small sample size in this study. Nevertheless, the reduction in contact area of the medial rearfoot during walking may be clinically significant. Both McConnell taping and the SERF strap also tended to reduce foot axis angle (no tape: 12.69±8.57 degrees, McConnell taping: 11.77±8.55 degrees,

SERF strap: 12.06±8.50 degrees, p = 0.216) which means that foot abduction and pronation decreased. Barton et al. (2010) [32] evaluated the foot posture in 15 young healthy volunteers and 15 volunteers with PFPS and found that significantly greater pronated foot posture between subtalar joint neutral and relaxed stance were indicated in PFPS group compared to healthy group. Levinger and Gilleard (2007) [33] measured rearfoot, tibia motion, and ground reaction force during the stance phase of walking in patients with PFPS and healthy individuals. The results indicated prolonged rearfoot eversion during the stance phase of walking in PFPS participants. Since individuals with PFPS produce higher foot pronation than healthy individuals, McConnell taping and SERF strap could be choices for individuals with PFPS to reduce foot pronation.

CONCLUSION

The applications of McConnell taping and the SERF strap resulted in significantly higher LH maximum pressures compared to the no-tape condition during walking. These results suggest that there could be a clinical role for McConnell taping or SERF strap use in reducing rearfoot pronation in people with lower extremity problems especially PFPS. Further studies should focus on the effect of the SERF strap and McConnell taping on plantar pressures in patients with PFPS.

ABBREVIATIONS

PFPS – Patellofemoral pain syndrome
VMO – Vastus medialis oblique
SERF – The Stability through External Rotation of the Femur
MH – Medial heel
LH – Lateral heel
COP – Centre of pressure

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