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Effects of Insoles on the Running Kinematics of Military Personnel with Patellofemoral Pain Syndrome

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5 List of tables and figures

5.1 List of tables

5.2 List of figures

6 List of abbreviations

% = percent

2D = two dimensional

3D = three dimensional

B-A = BorgInsole® – Aptonia®

B-G = BorgInsole® – Gespodo®

BMI = Body Mass Index

B-P = BorgInsole® - Phits®

cm = centimetres

CPD = contralateral pelvic distance

CPDA = contralateral pelvic drop angle

D3D = Direct 3 Dimensional

df = degrees of freedom

DF = double float

FC = foot crossover

FFS = forefoot strike

Fig = figure

FPPA = frontal plane projection angles

FS = footstrike

G-A = Gespodo® – Aptonia®

G-P = Gespodo® – Phits®

HAA = hip adduction angle

HIR = hip internal rotation

Hz = hertz

IC = initial contact

ICC = intraclass correlation coefficients

KFA = knee flexion angle

kg = kilograms

km/h = kilometres per hour

m = metres

MFS = midfoot strike

mm = millimetres

MS = midstance

MT = motorized treadmill

n = number of participants

N-A = no insole – Aptonia®

N-B = no insole – BorgInsole®

N-G = no insole – Gespodo®

N-P = no insole - Phits®

p = significance

P-A = Phits® - Aptonia®

PDI = Pain Disability Index

PFPS = patellofemoral pain syndrome

PSIS = posterior superior iliac spines

RFS = rearfoot strike

RSSS = running self-selected speed

SIA = shin inclination angle

SLL = single leg landing

SLS = single leg squatting

SPSS = Statistical Package for Social Science

TO = toe-off

7 Literature study

7.1 Abstract

Background: Patellofemoral pain syndrome (PFPS) is one of the most common injuries in runners (1). Several studies report the correlation between running kinematics and running overuse injuries such as PFPS (2,3). There is little conclusive evidence regarding the effectiveness of foot orthoses in rehabilitation (4). Insoles may be beneficial to influence running kinematics and thereby reduce patellofemoral joint stress.

Objective: The objective of the current study is to investigate whether foot orthoses have an influence on running kinematics in military personnel suffering PFPS, and therefore could be used in treatment.

Study design: cross-over study

Methods: Twenty-seven military personnel of the Belgian Defence with PFPS (male n = 16; female n = 11; age 30.56 ± 7.95 years) are included. Participants are compared with a control group of 42 subjects (male n = 27; female n = 15, age 27.95 ± 8.31 years). Each subject with PFPS wears two insoles for eight weeks. The 'Pain Disability Index' (PDI) questionnaire has to be filled out at the start and end of both intervention periods (5). The insole therapy consists of four types of orthotics, which are Phits®, BorgInsole®, Gespodo® and Aptonia®. The running analyses are performed on a treadmill at a self-selected speed (RSSS), 10 km/h and 12 km/h. A 2D video analysis is done to identify the running kinematics during different phases of the run cycle, specifically initial contact (IC), midstance (MS), toe-off (TO) and double float (DF). The observed running kinematics are contralateral pelvic drop angle (CPDA), hip adduction angle (HAA), knee flexion angle (KFA), shin inclination angle (SIA), footstrike (FS) and foot crossover (FC).

Results: CPDA and HAA are significantly larger in people with PFPS, while the SIA is smaller. The running speed can also significantly influence the kinematics, more specifically a larger HAA and smaller SIA at 12 km/h when compared to the other two speeds. There is a negative correlation between the kinematics CPDA and HAA, and between CPDA and KFA at a running speed of 10 km/h. While there is a positive correlation between HAA and KFA, and between HAA and FC. For all the other kinematics, no significant correlation is found. There is no significant difference in kinematics of subjects with PFPS between the four orthotics at baseline and after the intervention at 10 km/h. Furthermore, for the group that shows no improvement in PDI, significant differences are found for the kinematic variables KFA and SIA. There is a significant difference between no insole and Gespodo®, and between Gespodo® and Phits® for the variable KFA. For the variable SIA, a significant difference is found between no insole and Gespodo®, Gespodo® and Phits®, Gespodo® and BorgInsole®, and between Gespodo® and Aptonia®. For subjects who show an improvement in PDI score there are significant differences for the variable CPDA between Gespodo® and BorgInsole®, and for the variable HAA between no insole and Gespodo®, and between no insole and Phits®. Overall, no significant differences are found for all other kinematics.

Conclusion: Insoles influence the running kinematics. Nonetheless it is not possible to draw a general conclusion for the use of insoles in the treatment of PFPS due to non-homogeneous results and the multifactorial cause of PFPS.

Keywords: patellofemoral pain syndrome, foot orthoses, running kinematics, military personnel

7.2 Abstract (Dutch)

Achtergrond: Het patellofemoraal pijnsyndroom (PFPS) is een van de meest voorkomende blessures bij hardlopers (1). Verschillende studies melden de correlatie tussen de loopkinematica en overbelastingsletsels zoals PFPS (2,3). Er is weinig overtuigend bewijs voor de effectiviteit van inlegzolen bij revalidatie (4). Inlegzolen kunnen misschien nuttig zijn om de loopkinematica te beïnvloeden en daardoor de belasting op het patellofemoraal gewricht te verminderen.

Doel: Het doel van de huidige studie is om te onderzoeken of inlegzolen invloed hebben op de loopkinematica bij militairen met PFPS en of deze inlegzolen kunnen gebruikt worden in de behandeling van PFPS.

Opzet studie: cross-over studie

Onderzoeksmethode: Zevenentwintig proefpersonen van het militair personeel van de Belgische Defensie met PFPS (man n = 16; vrouw n = 11; leeftijd 30,56 ± 7,95 jaar) zijn geïncludeerd. De deelnemers worden vergeleken met een controlegroep van 42 proefpersonen (man n = 27; vrouw n = 15, leeftijd 27,95 ± 8,31 jaar). Elke proefpersoon met PFPS draagt twee inlegzolen, elk gedurende acht weken. De 'Pain Disability Index' (PDI) vragenlijst moet worden ingevuld aan het begin en aan het einde van beide interventieperioden. De zooltherapie omvat vier soorten inlegzolen, namelijk Phits®, BorgInsole®, Gespodo® en Aptonia®. De loopanalyses worden uitgevoerd op een loopband aan een zelfgekozen snelheid (RSSS), 10 km/u en 12 km/u. Een 2D videoanalyse wordt uitgevoerd om de loopkinematica tijdens de verschillende fasen van de loopcyclus te identificeren, namelijk initieel contact (IC), midden van de steunfase (MS), afzet (TO) en zweeffase (DF). De waargenomen loopkinematica zijn contralaterale bekkenkanteling hoek (CPDA), heupadductiehoek (HAA), knieflexie hoek (KFA), scheenbeen hoek (SIA), voetlanding (FS) en voet kruising (FC).

Resultaten: CPDA en HAA zijn significant groter bij personen met PFPS, terwijl de SIA kleiner is. De loopsnelheid kan ook een significante invloed hebben op de kinematica, namelijk een grotere HAA en kleinere SIA bij 12 km/u wanneer deze vergeleken wordt met de andere twee snelheden. Bij een loopsnelheid van 10 km/u wordt een negatieve correlatie gevonden tussen de loopkinematica CPDA en HAA en tussen CPDA en KFA. Er is een positieve correlatie tussen HAA en KFA en tussen HAA en FC. Voor alle andere kinematica wordt geen significante correlatie gevonden. Er is geen significant verschil in kinematica bij proefpersonen met PFPS tussen de vier inlegzolen bij baseline en na de interventie bij 10 km/u. Verder worden voor de groep die geen verbetering in PDI-score laat zien, significante verschillen gevonden voor de variabelen KFA en SIA. Voor KFA is er een significant verschil tussen geen inlegzool en Gespodo® en tussen Gespodo® en Phits®. Voor SIA worden significante verschillen gevonden tussen geen inlegzool en Gespodo®, Gespodo® en Phits®, Gespodo® en BorgInsole® en tussen Gespodo® en Aptonia®. Voor proefpersonen met een verbetering van de PDI-score, zijn er significante verschillen voor de variabele CPDA tussen Gespodo® en BorgInsole®, en voor HAA tussen geen inlegzool en Gespodo®, en tussen geen inlegzool en Phits®. Voor alle andere kinematica worden geen significante verschillen gevonden.

Conclusie: Inlegzolen beïnvloeden de loopkinematica. Desondanks is het niet mogelijk een algemene conclusie te trekken voor het gebruik van inlegzolen bij de behandeling van PFPS wegens niet-homogene resultaten en de multifactoriële oorzaak van PFPS.

Trefwoorden: Patellofemoraal pijnsyndroom, inlegzolen, loopkinematica, militair personeel

7.3 Introduction

Running is a widely performed activity by people of all ages and is very accessible which will increase its popularity even further in the future (5). However, musculoskeletal injuries related to running are common (6). The incidence depends on the discipline and how experienced the runner is. Novice runners are twice as often injured. The discipline where the incidence rate is the highest, is in marathon runners. The majority of running-related musculoskeletal injuries are due to overuse (1). The anatomical regions most often concerned are the knee, ankle and foot. Patellofemoral pain syndrome (PFPS) is one of the most common injuries with a prevalence of 16,7% and an incidence of 6,3%.

Patellofemoral pain can be described as pain in or around the anterior knee that increases when the knee is flexed during weight-bearing activities (7). The pain may occur unilaterally or bilaterally (8). Typically, the pain worsens during squatting, running, sitting for prolonged periods or climbing and descending stairs. The pain is described as sharp which is localized below or around the kneecap. Some patients report an unstable feeling in the knee. This may be caused by poorer quadriceps contraction due to pain inhibiting the muscle.

It is a common overuse injury in initial military training, which involves a rapid increase in the volume and intensity of running (4). The cause of overuse lower limb injuries is multifactorial with abnormal gait biomechanics being recognized as a critical factor. The origins of lower limb injuries in recreational running are largely the same as in initial military training, specifically a rapid increase in training load or volume, allowing these findings to be extrapolated beyond the military setting.

Patellofemoral pain is primarily treated conservatively (9). A multimodal treatment strategy is most effective. Exercise interventions are effective for immediate decrease in pain and increase in function. The commonly used therapy options are open or closed chain exercises, strength training of the hip and knee joint, and flexibility training. Patellar taping, bracing, pharmacological agents and therapeutic ultrasound are also non-surgical treatment options. However, these interventions remain controversial in literature.

The value of foot orthoses in the prevention of overuse injuries has been documented in previous studies (4). However a consensus has not yet been reached about whether they can be used in the treatment of an overuse injury. It is likely that an insole influences the activation of the control musculature of the foot during walking and running. This may lead to a reduction of excessive pronation. However, these are only assumptions as it is still impossible to attribute these beneficial effects to a specific cause.

The purpose of this study is to answer four questions:

1. Is there a significant difference between the kinematics at the baseline of PFPS compared to control for three different running speeds?
2. Is there a correlation between the different kinematic variables of subjects with PFPS before the intervention (no insole)?
3. Is there a significant difference in kinematics of subjects with PFPS between the four types of insoles at the baseline (no insole) and after wearing the insoles compared to the baseline (no insole)?

4. Which types of insoles cause a significant difference in kinematics of subjects with PFPS in whom the PDI does or does not improve compared to the baseline (no insole)?

7.4 Methodology

7.4.1 Participants

Military personnel of the Belgian Defence with PFPS are recruited for this study. Subjects are included with an age range between 18 and 60 years, report of a minimum of a three month history of recurrent lower leg overuse injuries and a medical diagnosis of PFPS. The medical diagnosis of PFPS is made when a subject experiences anterior knee pain for more than six weeks and exhibits two of the following criteria on initial assessment: pain caused by direct compression of the patella against the femoral condyles with the knee in full extension, tenderness on palpation of the posterior surface of the patella, pain on resisted knee extension and pain with isometric quadriceps contraction against suprapatellar resistance with the knee in slight flexion (10). Exclusion criteria are the following: patients with knee problems other than patellofemoral pain, pre-existing orthotic use, previous surgery to lower extremities and/or lumbar spine, signs or symptoms suggestive of an acute injury and consent withdrawal. Only people with complaints on the right leg or both legs are analysed as only a posterior and right view are recorded during the running analysis. Participants are compared with a control group.

7.4.2 Protocol

Participants have received an explanation of the study protocol and have given written informed consent before testing. Identification of subjects has taken place after a medical consultation at the Center for Physical Medicine & Rehabilitation of the Military Hospital Queen Astrid. Anthropometric data, such as height and weight, are recorded before the first running analysis on the treadmill. Next, a plantar pressure measurement is used for risk quantification (4). The plantar pressure measurement is recorded with a plantar pressure plate, which is a two meters Advanced Footscan System® plate and is placed in the center of a fifteen meter track (11). All participants are asked to walk and run barefoot over the track at a self-selected speed for a couple of times until they feel comfortable in order to adjust their gait to feel as natural as possible. Five complete right and left footstrikes are recorded and analysed using the RSscan Footscan system® 9.0 software (12). Eight anatomical areas are identified by the pressure plate software (**Fig 1**).

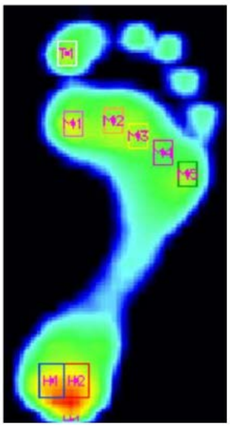

Figure 1: 8 anatomical areas identified by pressure plate software (4)

Temporal data on time to peak pressure, peak pressure and impact of the forefoot, midfoot and rearfoot are interpreted by the RSscan Footscan system® 9.0 software (12). The software determines a ratio for the three areas (**Table 1**). Should these ratios deviate from a range as determined by the manufacturer, a correction is recommended in this area of foot contact, to be applied to a custom orthosis with up to four areas of correction.

Table 1: Areas of orthotic correction and calculation pressure areas (4)

Correction	Calculation
A+: forefoot correction (antipronation)	(M1+M2)/(M1+M2+M3+M4+M5)
DF-: anti-inversion element, lateral stabilizer	(M3+M4+M5)/(M1+M2+M3+M4+M5)
B+: midfoot correction (antipronation)	(M1+M2+HM)/(M1+M2+M3+M4+M5+HM+HL)
C: rearfoot correction (antivalgus)	(HM)/(HM+HL)

H_M = medial heel; H_L = lateral heel; $M_{1\text{-}5}$ = metatarsal heads; A+, DF-, B+, C = areas for potential correction as applied to the orthoses

Depending on the number of corrections proposed by the D3D® System analysis, the biomechanical risk of each participant is graded in low, medium or high risk (4). There is no correction for the low risk group, one correction for the medium risk group and two or more corrections are made for the high risk group.

All subjects belonging to the medium or high risk group have to wear two different orthotic devices during an eight week period. Designation of an orthotic is done at random. A baseline assessment including 2D video analysis via Noraxon MyoVideo® (13) is performed at the beginning of the protocol and after each eight week period of wearing an insole.

7.4.3 Interventions

First, measurements are taken to make the orthotics. In this study, four different types of orthotics are used, specifically Phits®, BorgInsole®, Gespodo® and Aptonia®. Subjects are randomly assigned two different types of orthotics.

To manufacture the BorgInsole® the podiatrist takes a size measurement, determining the foot axes in unloaded, loaded and dynamic situations. Next, the 3D digitizer makes a highly accurate scan of both feet in their loaded, neutral position (14). The design for the insoles is made from the scans. It is a functional insole to correct the foot and improve dynamics (15). The insole is designed according to the biomechanical concept of walking and running and is based on dynamics. The foot is controlled according to its own axes. Thus, the influence of the function of the rearfoot, the subtalar joint, will have its logical movement transfer to the midfoot, the midtarsal joint, and the first ray. The goal is to have a shock absorption during the lowering of the foot and to create a rigid lever arm for stable repulsion. This in order to let the foot behave as ideally as possible during running and to be the most perfect link between the ground and the body. Because of the kinetic chain, this can have a positive impact on higher joints of ankle, knee, hip and back.

In the case of the Gespodo® insole, prints are made by a portable 3D scanner and the insoles are fabricated based on these prints (16,17).

For the Phits® insole, a dynamic scan of the gait is performed using the RSscan foot scanning system® (18,19). It directs your feet in the right direction to make your movement more efficient (19). It offers a customized solution to problems such as hyperpronation or -supination, heel spur and plantar fasciitis. The gait pattern is scanned and analysed, using a dynamic footscan system. Based on this, a design is generated. A 3D printer converts the digital design into orthotics. Finally, the 3D printed insoles are finished with a shock-absorbing comfort layer.

As last, the Aptonia® insole is an orthotic that can be bought in Decathlon (20). It is designed for more shock absorption while running.

Two weeks after deciding to participate in the study and taking measurements for the orthotics, the subjects endure a running analysis. Which functions as the baseline measurement. Next, the test subjects start wearing the first pair of orthotics. The orthotics are worn for eight weeks. During these eight weeks, normal training habits remain and the orthotics are worn during all physical activities. After wearing them for eight weeks, a second type of insoles are worn. The same applies to the second pair of orthotics. The total duration of the study per person is eighteen weeks.

The 2D running analyses are performed on a treadmill at a self-selected speed, 10 km/h and 12 km/h and takes fifteen seconds. If the self-selected speed is 10 or 12 km/h, there are only two measurements. A running analysis is executed before the subject has worn an insole and at the end of the eight week period of each type of insole. To measure the different angles during the running analyses, markers are placed on both posterior superior iliac spines (PSIS), two greater trochanter, lateral epicondyle of the femur of the right leg and the lateral malleolus of the right leg. A lateral (right side) and posterior view of the subject is recorded. During running analysis, it is recommended to use more than one video camera in order to measure more variables (21). As a consequence, it is more suitable to execute this indoors. The use of a treadmill is an ideal solution to analyse the running pattern because the runner remains in view. A control group of healthy volunteers is used as a match control group on gender and age. Running analyses are as well performed within the control group.

7.4.4 Outcomes

Different phases of the run cycle are analysed. During the stance phase, kinematic parameters are measured during initial contact (IC), midstance (MS) and toe-off (TO). Double float (DF) is the component of the swing phase which is further analysed. MyoVideo Noraxon® is part of the MR3 Software Noraxon® and is used to analyse 2D kinematics (13). It uses a multi-perspective video analysis tracking reflective markers. IC is the point in the run cycle when the foot initially touches the ground. This marks the beginning of the stance phase. MS is the first half of a single stance of the run cycle and is determined from the time the opposite limb leaves the floor until body weight is aligned over the forefoot. TO is the last contact of the foot with the ground (22). DF is when the pelvis is at its highest vertical position (23).

The analysis is executed of the right leg. For IC, the researched video fragment is placed at the first backward movement of the ankle. MS is investigated when both knees are aligned and the foot of the right leg is placed flat on the treadmill. The video fragment for TO is marked when the knee of the right leg is extended maximally. When the pelvis is at its highest position, the video fragment for DF is chosen. **Table 2** lists which parameters are measured during the different phases. Of each running analysis, five consecutive steps are analysed. Eleven kinematic parameters are measured for each step.

Table 2: Measured spatiotemporal parameters during the different phases of the run cycle

Joint/ Area	Initial contact	Midstance	Toe-off	Double float
Pelvis	Contralateral Pelvic Drop	Contralateral Pelvic Drop		Contralateral Pelvic Drop
Hip	Adduction	Adduction		Adduction
Knee	Flexion	Flexion	Flexion	
Shin	Shin Inclination			
Footstrike	RFS/ MFS/ FFS			
Foot Crossover		Foot Crossover		

The contralateral pelvic drop angle (CPDA) is determined by measuring the inclination of the line connecting both PSIS and the horizontal. The angle formed by the left and right greater trochanter and the lateral epicondyle of the right femur is the hip adduction angle (HAA).

At the level of the knee, the knee flexion angle (KFA) is measured. This is obtained by connecting the reflective markers placed at the greater trochanter, lateral epicondyle and lateral malleolus of the right leg. Shin inclination angle (SIA) is obtained by measuring the inclination of the connecting line between the lateral epicondyle and the lateral malleolus, and the vertical.

The footstrike (FS) is determined by which part of the foot touches the ground first during IC. There are three types: rearfoot, midfoot and forefoot strike. When the heel lands before the rest of the foot touches the ground, it is classified as a rearfoot strike (RFS). When the person has a midfoot strike (MFS), the heel and ball of the foot land simultaneously. A forefoot strike (FFS), also called toe-heel-toe run, is when the ball of the foot lands prior to the heel (24). To classify the foot crossover (FC), a vertical line is drawn in the middle of the line connecting both PSIS.

The CPDA, HAA, KFA and SIA are numerical variables. They are expressed by the number of degrees of the inclination (CPDA and SIA) or angle (HAA and KFA). The FS and FC are nominal variables. For FS, RFS scores zero, MFS one and FFS two. When the medial part of the heel does not touch the vertical line coming from the sacrum, the FC is scored as minus one. If it does touch the vertical line, a score of zero is given. When the medial part of the heel is on the inside of the vertical line, the FC has a score of one. The FC is scored as two when more than medial half of the heel is inside the vertical line.

7.4.5 Statistical analysis

Statistical Package for Social Science® (SPSS) version 28 is used (25). The running analyses are conducted by three researchers, specifically P.G., E.V. and F.V.. The intertester reliability and intratester reliability of the running analyses are calculated to verify the reliability of the measurements. For the intertester reliability, the three researchers analyse the same three individuals. From the analyses, numerical (CPDA, HAA, KFA and SIA) and categorical (FS and FC) data are obtained in each case. From these analyses, the intertester reliability is calculated in SPSS. For the numerical data, the intraclass correlation coefficients (ICC) are calculated through reliability analysis and the categorical data through Cohen's kappa. For intratester reliability, the three researchers analyse two subjects twice. From the obtained results, the intratester reliability is calculated. The numerical data are calculated through reliability analysis and the categorical data through descriptive statistics. The subjects for the intertester and intratester reliability assessments are chosen randomly.

The first analysis looks at whether there is a significant difference between the kinematics at the baseline of PFPS compared to control for three different running speeds. First, for the numerical variables, the Shapiro-Wilk test is performed to see whether the variables are normally distributed. For this, the 'test of normality' table in the 'Shapiro-Wilk' column is checked to see whether there is a significant difference. If they reach the level of significance, non-parametric tests are used. For speed, the Kruskal-Wallis test is used. The 'Test statistics' table looks at whether there is a significant difference. Next, the mean ranks in the table ‘Ranks’ are consulted to know which difference there is. For groups the Mann-Whitney U test is used. The table ‘Test statistics’ is considered to know whether there is a significant difference between the groups or not. The table ‘Ranks’ is used to know in which group the variable is larger. For the categorical variables, the Chi-square test is performed. The results of this test display what percentage has an expected count of less than five. If this is less than 20%, the Pearson Chi-Square in the table 'Chi-Square tests' is consulted. If the result is more than 20%, the likelihood ratio in the table 'Chi-Square tests' is considered.

The second analysis investigates the correlation between the different kinematic variables of subjects with PFPS before the intervention. The kinematics will be divided into CPDA, HAA, KFA, SIA, FS and FC. For this purpose, Pearson analysis is used to calculate the correlation between two numerical variables. Spearman analysis is used between two categorical variables and between a categorical and numerical variable.

For the third analysis, the kinematics of subjects with PFPS between the four types of insoles are compared at the baseline and after wearing the insoles compared to the baseline measurement. The baseline measurement is conducted as the test where subjects are not wearing orthotics. All subjects are analysed in this third part.

For the fourth analysis, the kinematics of subjects with PFPS between the four types of insoles are compared to the baseline and between the four insoles in patients in whom the PDI does or does not improve. The PDI is a questionnaire of seven items that examines self-reported pain disability, regardless of pain location or pain-related diagnosis (26). The questions are rated on a numerical rating scale from zero to ten. Score zero means no disability and score ten indicates maximum disability. The sum of the seven items is made, resulting in a total numerical value of zero to seventy. The higher the total score, the more the pain interferes with daily activity. The PDI measures family/home responsibilities, recreation, social activity, occupation, sexual behavior, self-care and life support activity. To know which subjects show an improvement in PDI score, the following rule is applied: a PDI base score of ≤27 must decrease at least seven points, a PDI base score between 28 and 42 must decrease at least with fifteen points, and subjects with a PDI base score ≥ 43 must decrease at least twenty points (26). To select the subjects with an improved PDI score or no improved PDI score, 'select cases' is used in SPSS.

To compare the kinematics in the third and fourth analysis, for the numerical variables, the Shapiro-Wilk test is first performed to see if the data is normally distributed. The variable is checked in the table 'tests of normality', in the 'Shapiro-Wilk' column, whether there is a significant difference. If it is not significant, it means the variable is normally distributed thus a parametric test, specifically the one-way ANOVA test is used to compare the groups. The data of which orthotics are worn, is placed under 'Factor' and the data of kinematics is placed in the 'dependent list'. This is done for the four different variables, specifically CPDA, HAA, KFA and SIA. In each case, these variables are still classified into the different stages of the step pattern, that are IC, MS, TO and DF. The descriptive statistics and Homogeneity of variance test is co-calculated. The 'tests of homogeneity of variances' table in the output is used to check whether there is a significant difference for each variable. If the difference is not significant, the ANOVA table may be interpreted (27). If the difference of the variable in the ANOVA table is significant, the post hoc test 'Tukey' is applied to see whether the differences between the groups are significant or not. If the difference is significant in the 'tests of homogeneity of variances' table, no post hoc test is performed, as the ANOVA table should then not be interpreted and thus does not contribute to answering the research question. The 'multiple comparisons' table is considered to know whether there is a significant difference between the groups. Only if the difference of the variable is significant in the ANOVA table, the post hoc test may be interpreted. For the variables that are not normally distributed, a non-parametric test, specifically the Kruskal-Wallis test is used. Here, the table ‘test statistics’ is considered. If the difference of the variable is significant, the Dunn’s test is performed to know whether there is a significant difference between the groups. For the categorical variables FS and FC, the Chi-Square test is performed. The table ‘Chi-Square test’ is considered to know whether there is a significant difference between the groups.

For the first research question, three different speeds are used. For the remaining three research questions, a running speed of 10 km/h is chosen because there are missing values for some subjects at a running speed of 12 km/h and the self-selected speed differs from one subject to another, which makes it impossible to draw general conclusions.

To know whether a significant difference is obtained, a significance level of 5% is used (28). If the p-value is smaller than 0.05, one can speak of statistical significance. It is hence accepted that there is a maximum 5% chance that the examined difference is still due to chance. In this case there is more than 95% certainty that what has been demonstrated in the study is actually true. If there is no significant difference, the null hypothesis may not be rejected. However, this does not mean that there cannot be significant differences within the groups.

7.5 Results

Thirty-eight military personnel of the Belgian Defence with PFPS are recruited for this study (male n = 27; female n = 11; age 28.79 ± 7.70 years). After applying the inclusion and exclusion criteria as described in the methodology, 27 subjects (male n = 16; female n = 11; age 30.56 ± 7.95 years) remained. An overview of the participant demographics can be found in **Table 3**. Reasons for exclusion are lost to follow-up and left knee complaints. **Figure 2** details the participants' flow. Across all participants, fifteen subjects (27.78%) have worn BorgInsole®, eleven subjects (20.37%) Gespodo®, fifteen subjects (27.78%) Phits® and thirteen subjects (24.07%) Aptonia®. The PFPS group is compared to a control group of 42 healthy volunteers (male n = 27, female n = 15; age 27.95 ± 8.31 years). The demographics of the control group can be consulted in **Table 4**.

Table 3: patient demographics

	Age (years)	**Height (cm)**	**Weight (kg)**	**BMI (kg/m²)**	**Side complaints**
Female (n=11)	32 ± 7.35	168.91 ± 8.76	62.09 ± 7.61	21.75 ± 2.01	4 bilateral 6 right 1 missing
Male (n=16)	29.56 ± 8.43	180.2 ± 7.11	81.6 ± 12.27	25.03 ± 2.52	5 bilateral 10 right 1 missing
All subjects (n=27)	30.56 ± 7.95	175.42 ± 9.56	73.35 ± 14.29	23.64 ± 2.81	9 bilateral 16 right 2 missing

Table 4: control group demographics

	Age (years)	**Height (cm)**	**Weight (kg)**	**BMI (kg/m²)**
Female (n = 15)	30.33 ± 8.432	164.8 ± 6.77	59.47 ± 7.558	21.86 ± 2.171
Male (n = 27)	26.63 ± 8.101	180.9 ± 5.48	74.78 ± 9.484	22.79 ± 2.153
All controls (n = 42)	27.95 ± 8.314	175.2 ± 9.79	69.31 ± 11.475	22.46 ± 2.179

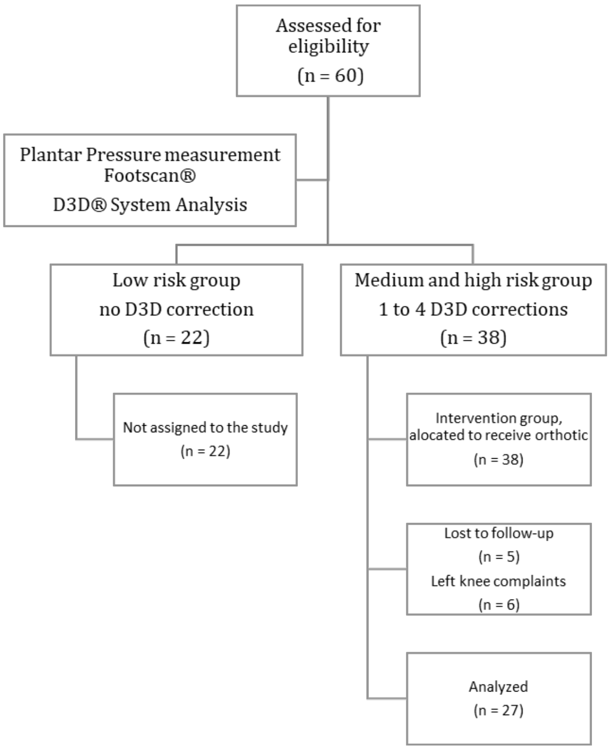

Figure 2: flow chart participants

The running kinematics during the different phases of the run cycle in 27 subjects are analysed by three researchers. Each researcher works separately. The categorical data consists of the variables FS and FC, and the numerical data comprises the variables CPDA, HAA, SIA and KFA. **Table 5** reports the intertester reliability for the categorical and numerical data. The intertester reliability of the categorical data has a kappa coefficient of 0.688 and the numerical data has an ICC of 0.999. The intratester reliability for the categorical and numerical data are shown in **Table 6**. The intratester reliability of the categorical data has a kappa coefficient of 0.802, 0.943 and 1. The numerical data has an ICC of 0.999, 1 and 0.998. ICC is located between zero and one. The closer the ICC value approaches one, the higher the reliability (27). For the kappa value, a score of 0.46 means moderate to good agreement. Hence, it can be concluded that both the intertester and intratester reliability are good.

Table 5: intertester reliability for measuring running kinematics

Variables	**Kappa**	**ICC**
Categorical	0.688 (p = 0.000)	
Numerical		0.999 (p = 0.000)

p = significance

Table 6: intratester reliability for measuring running kinematics

Variables	**Kappa**	**ICC**
Categorical researcher 1	0.802 (p < 0.001)	
Numerical researcher 1		0.999 (p = 0.000)
Categorical researcher 2	0.943 (p < 0.001)	
Numerical researcher 2		1.000 (p = 0.000)
Categorical researcher 3	1.000 (p < 0.001)	
Numerical researcher 3		0.998 (p = 0.000)

p = significance

The first research question investigates if there is a difference in the kinematics of subjects with PFPS in comparison to the control group and if there is a difference in the kinematics between the three different running speeds. The kinematics at a self-selected running speed and a running speed of 10 km/h and 12 km/h are examined. For the running speed, there is a significant difference for HAA and SIA. The HAA is larger at a running speed of 12 km/h and is the smallest at the self-selected running speed. This is the opposite for SIA where its value is larger at the self-selected speed and the smallest at 12 km/h. When comparing the control group with the patient population, a significant difference is found for CPDA, HAA and SIA. CPDA and HAA are bigger in people with PFPS, while the control group has a greater SIA. The results for the numerical kinematic variables can be consulted in **Table 7**. For the categorical variables, no significant difference is found when looking at the different speeds. For the groups however, FS and FC are both significantly different. In the PFPS group, 100% of the subjects have a RFS. The distribution for FS in the control group was the following: 93.23% RFS, 4.36% MFS and 2.42% has a FFS. The majority of the PFPS subjects score a one on the variable FC, while a score of zero is the most frequent given score in the control group. An overview of the results of the categorical kinematic variables can be consulted in **Table 8**.

Table 7: results for numerical kinematic variables of the first research question

Variable	**Kruskal-Wallis (speed)**	**Mann-Whitney (group)**
CPDA	not significant (p = 0.629)	significant (p < 0.001) PFPS > control
HAA	significant (p < 0.001) R12 > R10 > RSSS	significant (p < 0.001) PFPS > control
KFA	not significant (p = 0.757)	not significant (p = 0.430)
SIA	significant (p < 0.001) RSSS > R10 > R12	significant (p < 0.001) control > PFPS

CPDA = contralateral pelvic drop angle; HAA = hip adduction angle; KFA = knee flexion angle; P = significance; PFPS = Patellofemoral Pain Syndrome; SIA = shin inclination angle

Table 8: results for categorical kinematic variables of the first research question

Variable	Chi-square	
FS (speed)	not significant (p = 0.971)	
FS (group)	significant (p < 0.001)	
	PFPS (n = 400) RFS: 400 (100%) MFS: 0 (0%) FFS: 0 (0%)	control (n = 620) RFS: 578 (93.23%) MFS: 27 (4.36%) FFS: 15 (2.42%)
FC (speed)	not significant (P = 0.404)	
FC (group)	significant (P < 0.001)	
	PFPS (n = 400) -1: 49 (12.25%) 0: 153 (38.25%) 1: 164 (41%) 2: 34 (8.50%)	control (n = 620) -1: 93 (15%) 0: 383 (61.77%) 1: 141 (22.74%) 2: 3 (0.48%)

n = number of measurements; % = percentage; FC = foot crossover; FFS = forefoot strike; FS = footstrike; MFS = midfoot strike; p = significance; PFPS = Patellofemoral Pain Syndrome; RFS = rearfoot strike

Secondly, the correlation between the different kinematic variables of subjects with PFPS before the intervention at 10 km/h is examined. The results can be consulted in **Table 12** (see appendix) and the significant correlations are listed in **Table 9.** The results show that there is a negative correlation between CPDA and HAA and between CPDA and KFA, meaning that if CPDA increases, HAA decreases and vice versa (29). A positive correlation is found between HAA and KFA and between HAA and FC, meaning both variables increase or decrease together. For all the other kinematics, no significant correlation is found.

Table 9: significant correlations of the second research question

Variables	Significance	Pearson correlation	Spearman correlation
CPDA and HAA	<0.001	-0.557	
CPDA and KFA	<0.001	-0.656	
HAA and KFA	<0.001	0.428	
HAA and FC	<0.001		0.288

CPDA = contralateral pelvic drop angle; HAA = hip adduction angle; KFA = knee flexion angle; FC = foot crossover

The third research question concerns the investigation of a possible significant difference in kinematics of subjects with PFPS between the four types of insoles at the baseline and after wearing the insoles compared to the baseline at 10 km/h. Results are described in detail in **Table 13** (see appendix). When interpreting the results of the Shapiro-Wilk test, it can be concluded that 41 variables (68.33%) have a normal distribution and nineteen (31.67%) have a non-normal distribution. All calculations of the ANOVA test, Kruskal-Wallis test and Chi-Square test are non-significant therefore the results cannot be interpreted.

Finally, this study examines whether there is a significant difference in kinematics of subjects with PFPS in whom the PDI does or does not improve compared to the baseline and between the four insoles at 10 km/h. The results can be consulted in **Table 14 and 15** (see appendix) and the variables that show significant differences between groups are listed in **Table 10 and 11.** There are sixteen missing values (29.63%) in the initial score of the PDI and twenty missing values (37.04%) in the final score of the PDI (30). This means that eleven of the 27 subjects (40.74%) can be included for the analysis with an improved PDI score. Out of this group, there is one subject who has an improvement for both insoles. Due to the results of the Shapiro-Wilk test, it can be concluded that 41 variables (68.33%) have a normal distribution and nineteen variables (31.67%) have a non-normal distribution. Eighteen of the 27 subjects (66.67%) can be included for the analysis with no improved PDI score. Consulting the results of the Shapiro-Wilk test, it can be concluded that 44 variables (73.33%) have a normal distribution and sixteen variables (26.67%) have a non-normal distribution. Herewith, five subjects do not have an improved PDI score for both insoles. The same interpretation related to the tests is used for the second research question. In the group in which PDI improves, there is only one case for the Aptonia® orthotic. No results can be calculated for this insole as there need to be at least two cases.

For the subjects with no improvement on the PDI score, it is established that for the variable KFA, there is a significant difference between no insole and Gespodo® and between Gespodo® and Phits® for MS1 and TO1. Other significant differences are found for the variable SIA, this involving the Gespodo® insole. The result shows that there is a difference between no insole and Gespodo® and between Gespodo® and Phits® for IC1, IC3, IC4 and IC5, between Gespodo® and BorgInsole® for IC1, IC3 and IC5, and between Gespodo® and Aptonia® for IC3. For the other variables, no significant differences are found. For the subjects that have an improvement on the PDI score, it is established that for the variable CPDA, there is a significant difference between Gespodo® and BorgInsole® for IC4 and for the variable HAA, there is a significant difference between no insole and Gespodo® for DF3 and IC4. Finally, there is a significant difference between no insole and Phits® for MS1. For all the other kinematics, no significant differences are found.

Table 10: significant differences of the fourth research question, PDI not improved

Variable	Shapiro-Wilk	Homogeneity	ANOVA	Post hoc test from ANOVA
KFA				
MS1	0.381	0.084	0.032	N-G: 0.047 G-P: 0.036
TO1	0.792	0.932	0.024	N-G: 0.033 G-P: 0.047
SIA				
IC1	0.006	0.108	0.005	N-G: 0.048 G-B: 0.028 G-P: 0.003
IC3	0.003	0.969	<0.001	N-G: 0.003 G-B: 0.040 G-P: <0.001 G-A: 0.013
IC4	0.001	0.202	0.007	N-G: 0.021 G-P: 0.003
IC5	0.005	0.293	0.003	N-G: 0.005 G-B: 0.021 G-P: <0.001

N-G = No insole - Gespodo®; G-P = Gespodo® - Phits®; B-G = BorgInsole® - Gespodo®; G-A = Gespodo® - Aptonia®, KFA = knee flexion angle; SIA = shin inclination angle; IC = initial contact; MS = midstance; TO = toe-off

Table 11: results fourth research question, improved PDI

Variable	Shapiro- Wilk	Homogeneity	ANOVA	Post hoc test from ANOVA	Kruskal-Wallis	Post hoc test from Kruskal-Wallis
CPDA						
IC4	0.193	0.723	0.017	B-G: 0.046		
HAA						
MS1	<0.001				0.013	N-P: 0.004
DF3	0.352	0.415	0.010	N-G: 0.011		
IC4	0.068	0.294	0.027	N-G: 0.034		

B-G = BorgInsole® - Gespodo®; N-P = No insole - Phits®; N-G = No insole - Gespodo®; CPDA = contralateral pelvic drop angle; HAA = hip adduction angle; IC = initial contact; MS = midstance; DF = double float

7.6 Discussion

7.6.1 Result clarification

The objective of the current study is to investigate whether foot orthoses have an influence on running kinematics in military personnel suffering PFPS, and therefore could be used in treatment. To explore the subject, four research questions are developed. The four hypotheses are restated and discussed below. To obtain answers to the questions, an analysis of the running kinematics is performed by using MyoVideo Noraxon® (13).

Difference in kinematic variables between PFPS group and control group at RSSS, 10 km/h and 12 km/h

The first item questioned is whether there is a significant difference in kinematic variables between subjects with PFPS and a control group at the baseline at a self-selected running speed, 10 km/h and 12 km/h. Previous literature shows differences between subjects who develop PFPS and those who do not (31). Subjects who develop PFPS have greater mass and body mass index (BMI) compared to subjects who do not develop PFPS. Frontal plane projection angles (FPPA) and Q-angle, which are both indicative for knee valgus, of subjects with PFPS are significantly greater during single leg squatting (SLS), single leg landing (SLL) and running. They also have greater HAA during SLS and SLL. Additionally, this study has found a significantly larger HAA in the PFPS population during running. A large HAA contributes to excessive knee valgus, resulting in an increased contact pressure of the patellofemoral joint (32). PFPS also leads to a greater CPDA according to the results, which corresponds to previous investigation (33–35). An increased CPDA and HAA have been identified as important factors in running-related injuries and PFPS (3,36–41). When given visual and verbal feedback with the goal of decreasing CPDA and HAA as a therapy for PFPS in runners, significant improvements in pain and function are obtained (42). Barton et al. (43) states that a decreased KFA at heel strike and early stance is seen in individuals with PFPS. This is confirmed by Arazpour et al. (44). However, there is no consensus on KFA yet as this study and the study of Wirtz et al. has found no significant difference in KFA, and Bazett-Jones et al. has found an increased KFA in people with PFPS (45,46).

Comparing the kinematic variables at different speeds is interesting as they may differ. Literature states that step length and step frequency increase as speed linearly increases, this at the speeds 3.9, 4.17, 4.44, 4.72 and 5 m/s (47). In contrast, contact time and flight time decrease with increasing running speeds. This is interesting since increasing step frequency can be used in the rehabilitation of PFPS because it reduces patellofemoral joint forces (48). It is documented that using RSSS enhances natural biomechanics in each subject, while using standard speeds can lead to increased variability in relative muscle activity patterns, which can have an influence on the running kinematics (49). No significant difference is found in FS between the different investigated running speeds. In contrast to this research, it is shown that running speed influences the FS pattern (50). When speed increases, the odds of having a MFS and FFS increases. However, it has to be taken into account that the change in FS, for example, may result in loading tissue that is normally not stressed when running with one's usual pattern, leading to the possibility of sustaining a secondary injury (51). A small base of gait, more specifically a crossover, can lead to excessive load on tissues of the lower limb (52). In a healthy population, often a more narrow base of gait is present with increasing walking and running speeds.

Correlation between the kinematic variables

A second part of the investigation is whether there can be a correlation between the kinematic variables at the beginning of the study, before orthotics are worn. The running kinematics are analysed at a running speed of 10 km/h. After analysing the videos and performing statistics, significant correlations are found. The results show that there is a negative correlation between CPDA and HAA and between CPDA and KFA. Maykut et al. (35) has assumed a strong association between CPDA and HAA kinematics. Excessive pelvic drop during running contributes to excessive hip adduction, a variable that has been associated with numerous running injuries such as patellofemoral pain, iliotibial band syndrome and stress fractures to the tibia and metatarsals (2). Powers (53) has proposed that a CPDA during single-limb support may shift the center of mass away from the stance limb. As a compensation, excessive HAA and hip internal rotation (HIR) occurs, possibly resulting in genu valgum. Valgus can be linked to PFPS as it results in higher laterally directed forces on the patella. Injured runners exhibit greater contralateral pelvic distance (CPD) and forward trunk lean at MS and a more extended knee and dorsiflexed ankle at IC (54). CPD is found to be the most important variable in predicting the classification of participants as healthy or injured.

A positive correlation is found between HAA and KFA and between HAA and FC. Neal et al. (3) report that a larger KFA increases patellofemoral joint loading, with a smaller peak KFA also positively correlating with symptom reduction after incremental retraining. Runners with PFPS also have a significantly larger peak HAA compared to matched controls. A narrow stride width increases HAA (55). Therefore, minimizing crossover is a very effective strategy to help runners prevent lower extremity stress fractures and protect the joints in the long term.

Powers (53) also noted that the tibial rotation has an important influence on altered patellofemoral joint kinematics, which can be a cause of PFPS. Altered hip kinematics likely influence this concept. Some studies have found an increased HAA and HIR in female patients with PFPS during running (38,39), while other investigators did not find differences (56,57). If there is an excessive HAA and HIR, it causes the knee joint to move medially (35), which leads to abduction of the tibia and pronation of the foot. All these causes result in a dynamic valgus of the knee. A 2D analysis is executed which makes it impossible to investigate rotational kinematics (43). An increase in HAA and HIR might be explained by a decrease in muscle strength. Literature shows that participants who develop PFPS have lower hip abductor and knee extensor strength (31). In such cases, exercise therapy with strengthening of these muscles may be appropriate.

The relationship between different variables may be interesting to consider in rehabilitation. Suppose a variable in a running pattern is changed to decrease symptoms, it has to be kept in mind that the variables are correlated with each other and changing one variable may affect another variable.

Difference in kinematics between the four types of insoles

The effect of insoles on running kinematics examined in this study is not previously demonstrated in scientific literature. Franklyn-Miller et al. (4) states that foot orthoses can be used in the prevention of overuse lower limb injuries such as PFPS. Patellofemoral joint stress is an important factor in PFPS. Research shows that medial support insoles do not alter patellofemoral joint stress during running (58). When comparing shock absorbing and non-shock absorbing insoles, similar rates of lower limb injuries are observed for all insoles (59). The study provides no support for the use of shock absorbing insoles for military recruits.

This study examines the difference in kinematics between the four types of insoles. No significant differences are found when kinematics at baseline are taken into account, as well as running kinematics after wearing the insole are compared to the baseline at a running speed of 10 km/h. Therefore, the results cannot be interpreted. Later in the study, the effect of insoles on kinematic variables is discussed. It is shown that insoles have an effect on the variables, but the difference between the different orthotics cannot be demonstrated. This may be caused by the lack of significant differences between the different types of insoles or because the measurement methods cannot detect the differences. As a result, we cannot advice one insole.

Difference in kinematics in subjects whom PDI does or does not improve

Since kinematic variables have been shown to have an effect on injury risk in previous research, it may be interesting to examine the effect of the insoles on the variables in subjects whose PDI score does or does not improve (60).

In the subjects where there is no improvement, there are significant differences for the Gespodo® orthotic. For the variable KFA, there is a significant difference between no insole and Gespodo®, and between Gespodo® and Phits®. However, this has only been observed in MS1 and TO1, so caution in interpretation is necessary. It has been shown that increasing the KFA at ground contact can reduce the peak vertical ground reaction impact force, whereas a more extended knee angle at IC can increase the forces experienced by the body and therefore increase injury potential (60). As stated by multiple researchers, the KFA is often reduced in subjects with PFPS, more specifically at IC (43,44). Significant differences are also found for the variable SIA. There is a significant difference between no insole and Gespodo®, Gespodo® and Phits®, Gespodo® and BorgInsole®, and Gespodo® and Aptonia®. The difference between no insole and Gespodo® and Gespodo® and Phits® is the most prevalent, as this is observed in four out of five run cycles. There must be caution in interpreting the relationship between Gespodo® and Aptonia® since this has only been detected at IC3. For a runner suffering from impact-related running injuries, an extended knee is not ideal (2). This is when the lateral knee joint marker is behind the lateral malleolus marker. With a flexed knee, the runner can more easily dissipate the impact through knee flexion. Overstriding is defined as contact with the ground with a foot placed far ahead of the knee and hip (61). Meaning there is a great distance between the vertical projection of the body's center of mass on the ground and the point of FS. It occurs when a runner lands with the knee extended and leg at an extended angle. In other words, the greater the SIA, the greater the impact on joints and muscles. So, it is widely believed that overstriding increases the risk of injury.

In subjects where there is improvement, significant differences are found in two other variables, specifically CPDA and HAA. For CPDA a significant difference is found between Gespodo® and BorgInsole® during IC4. Excessive pelvic drop has previously been linked to PFPS (62). For the variable HAA a significant difference is found between no insole and Gespodo® during DF4 and IC4, and between no insole and Phits® during MS1. Again, interpreting the results have to be done with caution as they have not been observed very often. It is difficult to say with certainty that improvement in symptoms occurs due to the change in kinematics by the orthotics or possibly other factors since PFPS has a multifactorial cause (4,43). Also taking into account that many differences are not significant. In a trial where gait retraining is given to runners with PFPS, a significant reduction in HAA of five degrees and CPDA is found, as well as a reduction of pain by 86% (63). These results have persisted at the one month follow-up. Willy et al. (41) have reported that hip adduction is increased in patients with PFPS and is more present in the female subjects in comparison to the male subjects. In a study of Franklyn-Miller et al. (4), military personnel with overuse injuries of the lower limb, such as medial tibial stress syndrome and tibial stress fracture, are given a D3D orthosis. The intervention group has an absolute risk reduction of 0.49. The question of which mechanism takes place and to what beneficial effect can be attributed, cannot yet be answered. We have no information regarding the Aptonia® insole since there are no two subjects who showed improvement with this insole. As a result, they cannot be compared.

7.6.2 Limitations and strengths

Testing and intervention

The current study has several limitations. Results are often not homogeneous, and it is difficult to identify tendencies which can be generalized across the insole that has been tested. Therefore, clear and strong conclusions are difficult to make based on the outcomes of this study.

In addition, a limited arsenal of kinematic variables is taken into account. The effect of trunk, upper limb, cadence and stride length have not been examined, whereas these may also affect the injury potential. Research shows that running at an increased cadence reduces patellofemoral joint stress (64). This is also described by Lenhart et al. (48) as an effective strategy to reduce patellofemoral joint forces and can be effective in modulating biomechanical factors that can contribute to patellofemoral pain. Increasing step rate decreases peak stance phase knee flexion and is found to be the most important predictor of the reduction in patellofemoral joint loading.

All tests are performed on a treadmill. Recent literature states that kinematic outcome measures are largely comparable between motorized treadmill (MT) and overground running (65). Although, we have to be cautious when interpreting the kinematics in the sagittal plane. Ankle dorsiflexion and KFA will be larger when running on a MT. This while the hip flexion angle is reported to be smaller. Increased knee flexion and ankle dorsiflexion at IC during MT running can reflect a compensatory strategy to reduce lower extremity stiffness when running on a stiff MT running surface compared to a more compliant overground surface. Riley et al. (66) find that treadmill walking is qualitatively and quantitatively very similar to overground gait and differences are within the range of normal variability of gait parameters. This may also be possible for treadmill running, but no conclusive research has been executed on this topic yet.

A strength is the 2D video analysis, used to record running patterns. It is proven that a 2D video analysis is a proper alternative to a 3D video analysis for measuring frontal plane angles such as HAA and CPDA (5,35). Furthermore, there is an excellent intra- and intertester reliability for all 2D kinematic outcomes (67).

To know whether this study has an acceptable sample size, the expected sample size is calculated using the software G*Power 3.1.9.7® (68). The expected sample size can be calculated based on three components: the statistical power, the significance level and the effect size (54). The ideal power of a study is considered to be 0.8, the significance level used is 0.05 and the average effect size of five similar studies is 0.38 (53,69–73). This leads to an expected sample size of 39 ± 37 df. For the first research question, a total of 69 subjects are used, which means there is a sufficient sample size. However, for the remaining three research questions, the sample size is too small as for the second and third research question 27 subjects are used and for the last 29 subjects are eligible as eleven subjects have an improved PDI and eighteen have not. As a consequence, the sample size is too small for these analyses.

An additional strength of this study is that the subjects are testing two different orthotics, so individual differences cannot account for any differences between conditions. The use of this method increases the power of the study. It would have been even better if all the subjects with PFPS are wearing all four orthotics. However, this would severely increase the duration of the study.

Data analysis

During the analysis of the video footage some problems are encountered. First, the guidelines are not always correct. For example, with IC, the guidelines state that angles have to be measured at the first backward movement of the foot. However, it occasionally happened that at the first backward movement of the foot, the foot clearly did not touch the treadmill yet. To maximize intertester reliability, each researcher followed the guidelines.

Confusion also occurred at times concerning the markers. The task is to indicate the center of the marker. This is done by sight and small shifts on position give several degrees of difference. In some cases, the markers are not clearly visible because the hand or handrail of the treadmill is in front of them, in which case an estimation has to be made about where the marker is approximately located. The approximate location is determined by comparison of the last and first consequent frame where the marker is visible. Other reflectors on clothing or shoes have caused confusion as to where the marker is applied by researchers. Additionally, the marker sometimes shifts position while running, decreasing the accuracy of the data.

The poor image quality does not always allow easy differentiation of the different phases. For example in TO, it is sometimes hard to see when the shoe leaves the treadmill. This becomes even more difficult if the runner is wearing black shoes. When in doubt, there is negotiation among the researchers until a consensus is reached.

The PDI scores of some patients are missing and have to be labelled as a missing value (30).

Despite all these obstacles, there is still a good intratester and intertester reliability regarding the analysis of the video footage.

Result interpretation

It has to be considered that all subjects analysed have a heel strike technique. Xu et al. (74) report that there is no significant difference in KFA and hip flexion angle between the FFS and RFS runners, although hip flexion and knee flexion excursion are significantly decreased in the FFS runners compared to the RFS runners. There are higher biomechanical loads of total impact on the ground, knee and patellofemoral joints while running with a RFS compared to running with a FFS. An increase in patellofemoral joint stress can cause patellofemoral pain (75). A FFS produces higher biomechanical loads on the ankle joint and Achilles tendon (74). Another consequence of a monotonic FS in the PFPS population is that many statistical tests give no results. Due to this consequence FS calculations are not listed in the appendix.

Orthotics can modify the perception of comfort and motor control (76). The colors of the orthotics can also have an impact on the effect of the orthotics. From the study by Channasanon et al. (77), it is concluded that there is no significant differences in plantar pressure distribution between the 3D printed and prefabricated medial arch supports. However, the 3D printed medial arch supports have resulted in better comfort than the prefabricated arch support. The material hardness has no apparent effect on plantar pressure distribution.

The expertise of the researchers is another limitation in the result interpretation. Even though physical therapy students have a considerable amount of knowledge about running pattern, kinematic variables and PFPS, there is a lack of expertise regarding insoles and their effect on kinematic variables and PFPS.

7.7 Conclusion

The study investigates the effect of insoles on running kinematics in military personnel with PFPS. It can be concluded that some kinematics of the PFPS subjects differ from the kinematics of the control group and that running speeds also has its influence on these variables. There is also a correlation between the different kinematics at the baseline. It has to be taken into account that changing one kinematic variable in the running pattern can influence another variable. Changing CPDA will change HAA and KFA and changing HAA will change KFA and FC as well.

No differences in running kinematics can be found between the four types of insoles at the baseline and after intervention. This does not mean that the insoles do not affect kinematics, perhaps the insoles are just too similar and it does not matter which insole is used.

In the fourth analysis, insoles affect running kinematics. In subjects without improvement in PDI score, Gespodo® provides a different angle in KFA and SIA. Gespodo® has the most changes in these variables compared to the other orthotics. Gespodo® probably causes a smaller KFA angle and a larger SIA angle, which does not improve the PDI score.

For subjects with an improvement in PDI score, Gespodo® and Phits® have a different HAA compared to the subjects with no insoles. Gespodo® also has a different CPDA compared to BorgInsole®. So wearing Gespodo® and Phits® probably reduces the angles.

It is not possible to draw a general conclusion for the use of insoles in the treatment of PFPS due to non-homogeneous results in the different steps and the multifactorial cause of PFPS. This does not mean that orthoses cannot be used as a method of therapy, as they may affect other factors important in the development of PFPS. Further research is needed for other kinematic variables such as tibial and femoral rotation, hyperpronation of the foot, kinematics of the trunk and upper limb as they can also influence the kinematics used in this study and the origination of PFPS. Further research is also needed for the effect of age, gender, a non-standardized setting and other different running speeds. Finally, a more thorough investigation of the different phases of running can be useful.

7.8 References

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8 Abstract in layman's terms

Achtergrond: Eén van de meest voorkomende letsels bij hardlopers is het patellofemoraal pijnsyndroom (PFPS), dit is een overbelastingsletsel ter hoogte van de knie (1). Hierbij kan je pijn hebben rond de voorkant van je knie. Verschillende studies tonen aan dat er een verband is tussen de looptechniek en overbelastingsletsels zoals PFPS (2,3). Er is nog niet veel bewijs voor de effectiviteit van inlegzolen bij de revalidatie van PFPS (4). Inlegzolen zouden nuttig kunnen zijn om de looptechniek te beïnvloeden en daardoor de belasting op het kniegewricht te verminderen.

Doel: Het doel van deze studie is om te onderzoeken of verschillende inlegzolen invloed hebben op de looptechniek bij militairen met PFPS en of deze inlegzolen kunnen gebruikt worden in de behandeling van PFPS..

Onderzoeksmethode: Het effect van vier verschillende inlegzolen wordt onderzocht op deze knieklachten bij 27 militairen met PFPS. Ze hebben elk twee inlegzolen gedragen gedurende acht weken. Voor en nadat de zolen werden gedragen, zijn er loopanalyses uitgevoerd. Hiervoor hebben de proefpersonen gelopen op een loopband aan drie verschillende snelheden en dit werd telkens gefilmd. Met de resultaten wordt er geëvalueerd op welke manier de personen lopen aan de hand van reflecterende markers op hun lichaam. Deze proefpersonen zijn vergeleken met een controlegroep van 42 gezonde personen. Voor en na het dragen van iedere zool is er ook een pijnschaal ingevuld om te weten of de inlegzool effect heeft gehad op de pijn of niet. Voor elke zool worden verschillen in de looptechniek voor en na het dragen van de zolen geëvalueerd. Dit wordt ook vergeleken met de controlegroep.

Resultaten: Zowel PFPS als de loopsnelheid kunnen een invloed hebben op de looptechniek. Zo zal bijvoorbeeld het bekken meer zakken bij PFPS. Er is ook een verband tussen verschillende onderdelen van de looptechniek. Zo beïnvloedt de bekkenkanteling de mate waarin de heupen en knieën worden geplooid, die op hun beurt een invloed hebben op hoe breed de voeten van elkaar worden geplaatst. Dit kan er voor zorgen dat het normaliter onbelaste weefsel belast wordt, waardoor een blessure kan ontstaan. Er is geen verschil in looptechniek tussen de vier soorten inlegzolen voor en na het dragen ervan. De Gespodo® zool zorgt waarschijnlijk voor een kleinere buiging van de knie en een grotere hoek tussen scheenbeen en de horizontale, waardoor de pijn niet vermindert. Anderzijds zorgen de Gespodo® en Phits® zolen waarschijnlijk voor een meer gestrekte heup en bekkenkanteling, wat wel zorgt voor een vermindering van pijn.

Conclusie: De kniepijn heeft meerdere oorzaken en de resultaten zijn niet altijd eenduidig. Hierdoor kan er niet gezegd worden dat inlegzolen 'de' oplossing zijn voor kniepijn. Dit wil echter niet zeggen dat ze niet kunnen worden gebruikt als behandeling, aangezien ze wel een invloed hebben op de looptechniek.

Trefwoorden: patellofemoraal pijnsyndroom, inlegzolen, looptechniek, militair personeel

9 Proof of submission to the Ethics Committee

C H U - U V C
BRUGMANN

Réf. : CE 2017/54

COMITE D'ETHIQUE HOSPITALIER
OM 026
Secrétariat
☎ *02 / 477.39.16*
02 / 477.39.20

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14/03/2017

Président
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Dr B. PEPERSTRAETE
Mme L. DE BEER
Mme K. PAEMELAERE
Mme M. EUCHER
M. O. BROWN
M. C. NYS
M. E. SIMONS

Cher Mr Bernard,

Concerne :
Influence of dynamic orthotic devices on lower limb overuse injuries of the military personnel.
B077201731826

Le Comité d'Ethique Hospitalier du C.H.U. BRUGMANN a pris connaissance du protocole d'étude dont l'intitulé est repris sous rubrique.

Formulaire de demande interne
Protocole
Document d'information et de consentement éclairé
CV Damien Van Tiggelen – Eric Bernard

Le comité d'éthique marque son accord.

Nous vous prions de croire, Monsieur, en l'assurance de nos sentiments les meilleurs.

Docteur P. VERBANCK,
Secrétaire

Docteur J. VALSAMIS,
Président

Le Comité d'Ethique rappelle que les amendements substantiels et les notifications de sécurité, comme décrites dans la loi du 7 mai 2004, doivent lui être soumis.

Site HORTA

Site BRIEN

Site ASTRID

10 Appendix

Table 12: results second research question

Variables	**Significance**	**Pearson correlation**	**Spearman correlation**
CPDA and HAA	Significant <0.001	-0.557	
CPDA and KFA	Significant <0.001	-0.656	
CPDA and SIA	Not significant 0.184	0.115	
CPDA and FS	Not significant		/
CPDA and FC	Not significant 0.356		-0.080
HAA and KFA	Significant <0.001	0.428	
HAA and SIA	Not significant 0.169	-0.019	
HAA and FS	Not significant		/
HAA and FC	Significant <0.001		0.288
KFA and SIA	Not significant 0.936	-0.007	
KFA and FS	Not significant		/
KFA and FC	Not significant 0.467		-0.063
SIA and FS	Not significant		/
SIA and FC	Not significant 0.888		-0.012
FS and FC	Not significant		/

CPDA = contralateral pelvic drop angle; HAA = hip adduction angle; KFA = knee flexion angle; SIA = shin inclination angle; FS = footstrike; FC = foot crossover

Table 13: results third research question

Variable	Shapiro-Wilk	Homogeneity	ANOVA	Kruskal-Wallis	Chi-square (X²) test
CPDA					
IC1	Not significant 0.371	Not significant 0.994	Not significant 0.756		
MS1	Significant 0.013			Not significant 0.969	
DF1	Not significant 0.661	Not significant 0.757	Not significant 0.963		
IC2	Not significant 0.290	Not significant 0.797	Not significant 0.986		
MS2	Significant 0.046			Not significant 0.958	
DF2	Not significant 0.322	Not significant 0.893	Not significant 0.972		
IC3	Not significant 0.182	Not significant 0.829	Not significant 0.998		
MS3	Not significant 0.139	Not significant 0.494	Not significant 0.715		
DF3	Not significant 0.722	Not significant 0.846	Not significant 0.949		
IC4	Not significant 0.458	Not significant 0.680	Not significant 0.749		
MS4	Significant 0.006			Not significant 0.963	
DF4	Not significant 0.919	Not significant 0.472	Not significant 0.976		
IC5	Not significant 0.154	Not significant 0.525	Not significant 0.987		
MS5	Significant 0.005			Not significant 0.841	
DF5	Not significant 0.801	Not significant 0.515	Not significant 0.994		
HAA					
IC1	Not significant 0.671	Not significant 0.657	Not significant 0.258		
MS1	Significant <0.001			Not significant 0.881	
DF1	Not significant 0.707	Not significant 0.540	Not significant 0.419		
IC2	Not significant 0.604	Not significant 0.603	Not significant 0.417		
MS2	Not significant 0.560	Not significant 0.492	Not significant 0.948		
DF2	Not significant 0.298	Not significant 0.944	Not significant 0.267		
IC3	Not significant 0.599	Not significant 0.905	Not significant 0.331		
MS3	Not significant 0.375	Not significant 0.310	Not significant 0.530		
DF3	Not significant 0.397	Not significant 0.244	Not significant 0.208		
IC4	Not significant 0.225	Not significant 0.111	Not significant 0.202		

MS4	Not significant 0.594	Not significant 0.747	Not significant 0.579		
DF4	Not significant 0.646	Not significant 0.563	Not significant 0.373		
IC5	Not significant 0.355	Not significant 0.826	Not significant 0.365		
MS5	Not significant 0.821	Not significant 0.420	Not significant 0.821		
DF5	Not significant 0.526	Not significant 0.812	Not significant 0.429		
KFA					
IC1	Significant <0.001			Not significant 0.463	
MS1	Not significant 0.585	Not significant 0.062	Not significant 0.120		
TO1	Not significant 0.723	Not significant 0.493	Not significant 0.122		
IC2	Significant <0.001			Not significant 0.369	
MS2	Not significant 0.660	Not significant 0.224	Not significant 0.145		
TO2	Not significant 0.505	Not significant 0.776	Not significant 0.157		
IC3	Significant <0.001			Not significant 0.592	
MS3	Not significant 0.650	Not significant 0.058	Not significant 0.271		
TO3	Not significant 0.918	Not significant 0.835	Not significant 0.306		
IC4	Significant <0.001			Not significant 0.542	
MS4	Not significant 0.498	Not significant 0.189	Not significant 0.196		
TO4	Not significant 0.574	Not significant 0.675	Not significant 0.166		
IC5	Significant <0.001			Not significant 0.324	
MS5	Not significant 0.922	Not significant 0.347	Not significant 0.433		
TO5	Not significant 0.249	Not significant 0.724	Not significant 0.296		
SIA					
IC1	Significant 0.009			Not significant 0.955	
IC2	Not significant 0.140	Significant 0.012	/ do not interpret		
IC3	Significant 0.012			Not significant 0.606	
IC4	Significant <0.001			Not significant 0.732	
IC5	Significant 0.021			Not significant 1.000	
FC					
MS1					Not significant 0.497

MS2					Not significant 0.837
MS3					Not significant 0.646
MS4					Not significant 0.404
MS5					Not significant 0.531

CPDA = contralateral pelvic drop angle; HAA = hip adduction angle; KFA = knee flexion angle; SIA = shin inclination angle; FS = footstrike; FC = foot crossover; IC = initial contact; MS = midstance; TO = toe-off; DF = double float

Table 14: results fourth research question, PDI not improved

Variable	Shapiro-Wilk	Homogeneity	ANOVA	Post hoc test from ANOVA	Kruskal-Wallis	Chi-square (X²) test
CPDA						
IC1	Not significant 0.681	Not significant 0.972	Not significant 0.754			
MS1	Significant 0.017				Not significant 0.435	
DF1	Not significant 0.849	Not significant 0.640	Not significant 0.684			
IC2	Not significant 0.564	Not significant 0.677	Not significant 0.598			
MS2	Not significant 0.149	Not significant 0.340	Not significant 0.708		Not significant 0.903	
DF2	Not significant 0.340	Not significant 0.764	Not significant 0.617			
IC3	Not significant 0.231	Not significant 0.990	Not significant 0.764			
MS3	Not significant 0.100	Not significant 0.119	Not significant 0.581			
DF3	Not significant 0.723	Not significant 0.536	Not significant 0.813			
IC4	Not significant 0.527	Not significant 0.891	Not significant 0.807			
MS4	Significant <0.001					
DF4	Not significant 0.857	Not significant 0.581	Not significant 0.529			
IC5	Not significant 0.101	Not significant 0.857	Not significant 0.576			
MS5	Significant 0.026				Not significant 0.320	
DF5	Not significant 0.884	Not significant 0.560	Not significant 0.871			
HAA						
IC1	Not significant 0.391	Not significant 0.625	Not significant 0.469			
MS1	Not significant 0.374	Not significant 0.584	Not significant 0.886			

DF1	Not significant 0.664	Not significant 0.476	Not significant 0.289			
IC2	Not significant 0.667	Not significant 0.755	Not significant 0.590			
MS2	Not significant 0.649	Not significant 0.558	Not significant 0.899			
DF2	Not significant 0.483	Not significant 0.714	Not significant 0.115			
IC3	Not significant 0.490	Not significant 0,366	Not significant 0.298			
MS3	Not significant 0.450	Not significant 0,133	Not significant 0.520			
DF3	Significant 0.037				Not significant 0.828	
IC4	Significant 0.047				Not significant 0.393	
MS4	Not significant 0.944	Not significant 0.354	Not significant 0.855			
DF4	Not significant 0.489	Not significant 0.378	Not significant 0.272			
IC5	Not significant 0.251	Not significant 0.160	Not significant 0.403			
MS5	Not significant 0.891	Not significant 0.234	Not significant 0.921			
DF5	Not significant 0.213	Not significant 0.673	Not significant 0.370			
KFA						
IC1	Significant <0.001				Not significant 0,.258	
MS1	Not significant 0.381	Not significant 0.084	Significant 0.032	N-B: 1.000 N-G: 0.047 N-P: 0.977 N-A: 0.526 B-G: 0.147 B-P: 0.999 B-A: 0.780 G-P: 0.036 G-A: 0.529 P-A: 0.395		
TO1	Not significant 0.792	Not significant 0.932	Significant 0.024	N-B: 0.953 N-G: 0.033 N-P: 1.000 N-A: 0.317 B-G: 0.334		

				B-P: 0.946 B-A: 0.956 G-P: 0.047 G-A: 0.588 P-A: 0.401		
IC2	Significant <0.001				Not significant 0.379	
MS2	Not significant 0.446	Not significant 0.154	Not significant 0.055			
TO2	Not significant 0.211	Not significant 0.378	Not significant 0.066			
IC3	Significant <0.001				Not significant 0.429	
MS3	Not significant 0.343	Not significant 0.133	Not significant 0.119			
TO3	Not significant 0.726	Not significant 0.481	Not significant 0.094			
IC4	Significant <0.001				Not significant 0.311	
MS4	Not significant 0.521	Significant 0.039	/ do not interpret			
TO4	Not significant 0.270	Not significant 0.409	Not significant 0.072			
IC5	Significant <0.001				Not significant 0.362	
MS5	Not significant 0.810	Not significant 0.093	Not significant 0.104			
TO5	Not significant 0.332	Not significant 0.497	Not significant 0.089			
SIA						
IC1	Significant 0.006	Not significant 0.108	Significant 0.005	N-B: 0.786 N-G: 0.048 N-P: 0.208 N-A: 0.982 B-G: 0.028 B-P: 0.997 B-A: 0.669 G-P: 0.003 G-A: 0.202 P-A: 0.238		
IC2	Not significant 0.216				Not significant 0.124	
IC3	Significant 0.003	Not significant 0.969	Significant <0.001	N-B: 0.999 N-G: 0.003		

				N-P: 0.193 N-A: 1.000 B-G: 0.040 B-P: 0.501 B-A: 1.000 G-P: <0.001 G-A: 0.013 P-A: 0.413		
IC4	Significant 0.001	Not significant 0.202	Significant 0.007	N-B: 0.997 N-G: 0.021 N-P: 0.499 N-A: 0.798 B-G: 0.167 B-P: 0.681 B-A: 0.990 G-P: 0.003 G-A: 0.230 P-A: 0.210		
IC5	Significant 0.005	Not significant 0.293	Significant 0.003	N-B: 0.995 N-G: 0.005 N-P: 0.545 N-A: 0.893 B-G: 0.021 B-P: 0.972 B-A: 0.881 G-P: <0.001 G-A: 0.073 P-A: 0.315		
FC						
MS1						Not significant 0.294
MS2						Not significant 0.878
MS3						Not significant 0.283
MS4						Not significant 0.324
MS5						Not significant 0.491

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Table 15: results fourth research question, improved PDI

Variable	Shapiro- Wilk	Homogeneity	ANOVA	Post hoc test from ANOVA	Kruskal-Wallis	Post hoc test from Kruskal-Wallis	Chi-square (X^2) test
CPDA							
IC1	Not significant 0.330	Not significant 0.706	Significant 0.042	N-B: 0.566 N-G: 0.109 N-P: 0.630 B-G: 0.052 B-P: 0.261 G-P: 0.901			
MS1	Significant 0.013				Not significant 0.325		
DF1	Not significant 0.131	Not significant 0.443	Not significant 0.496				
IC2	Not significant 0.260	Not significant 0.370	Not significant 0.204				
MS2	Not significant 0.107	Not significant 0.834	Not significant 0.792				
DF2	Not significant 0.154	Not significant 0.772	Not significant 0.311				
IC3	Not significant 0.246	Not significant 0.584	Not significant 0.110				
MS3	Not significant 0.121	Not significant 0.789	Not significant 0.375				
DF3	Not significant 0.340	Not significant 0.682	Not significant 0.090				
IC4	Not significant 0.193	Not significant 0.723	Significant 0.017	N-B: 0.547 N-G: 0.100 N-P: 0.230 B-G: 0.046 B-P: 0.088 G-P: 0.999			
MS4	Significant 0.009				Not significant 0.249		

DF4	Not significant 0.413	Not significant 0.476	Not significant 0.328				
IC5	Significant 0.038				Not significant 0.186		
MS5	Significant 0.008				Not significant 0.336		
DF5	Not significant 0.248	Not significant 0.535	Not significant 0.342				
HAA							
IC1	Not significant 0,555	Not significant 0.303	Not significant 0.137				
MS1	Significant <0,001				Significant 0.013	N-B: 0.403 N-G: 0.056 N-P: 0.004 B-G: 0.501 B-P: 0.134 G-P: 0.354	
DF1	Not significant 0,261	Not significant 0.123	Not significant 0.055				
IC2	Not significant 0,172	Not significant 0.089	Not significant 0.113				
MS2	Not significant 0,602	Not significant 0.603	Not significant 0.218				
DF2	Not significant 0,134	Not significant 0.192	Not significant 0.076				
IC3	Not significant 0,255	Not significant 0.269	Not significant 0.064				
MS3	Not significant 0,352	Not significant 0.367	Significant 0.048	N-B: 0.678 N-G: 0.287 N-P: 0.092 B-G: 0.982 B-P: 0.768 G-P: 0.910			
DF3	Not significant	Not	Significant	N-B: 1.000			

	0,352	significant 0.415	0.010	N-G: 0.011 N-P: 0.316 B-G: 0.101 B-P: 0.548 G-P: 0.777			
IC4	Not significant 0.068	Not significant 0.294	Significant 0.027	N-B: 0.998 N-G: 0.034 N-P: 0.303 B-G: 0.261 B-P: 0.637 G-P: 0.932			
MS4	Not significant 0.716	Not significant 0.580	Not significant 0.241				
DF4	Not significant 0.129	Not significant 0.316	Not significant 0.099				
IC5	Not significant 0.236	Not significant 0.255	Not significant 0.117				
MS5	Not significant 0.437	Not significant 0.295	Not significant 0.256				
DF5	Not significant 0.149	Not significant 0.603	Not significant 0.114				
KFA							
IC1	Not significant 0.640	Not significant 0.122	Not significant 0.613				
MS1	Not significant 0.370	Not significant 0.822	Not significant 0.560				
TO1	Not significant 0.525	Not significant 0.819	Not significant 0.658				
IC2	Significant 0.033				Not significant 0.912		
MS2	Not significant 0.661	Not significant 0.378	Not significant 0.376				

TO2	Not significant 0.879	Not significant 0.694	Not significant 0.723				
IC3	Significant 0.023				Not significant 0.872		
MS3	Not significant 0.314	Not significant 0.827	Not significant 0.670				
TO3	Not significant 0.801	Not significant 0.720	Not significant 0.426				
IC4	Not significant 0.098	Not significant 0.589	Not significant 0.711				
MS4	Not significant 0.320	Not significant 0.206	Not significant 0.712				
TO4	Not significant 0.421	Not significant 0.901	Not significant 0.541				
IC5	Not significant 0.264	Not significant 0.412	Not significant 0.832				
MS5	Not significant 0.304	Not significant 0.349	Not significant 0.874				
TO5	Not significant 0.230	Not significant 0.882	Not significant 0.598				
SIA							
IC1	Significant 0.005				Not significant 0.070		
IC2	Not significant 0.113	Not significant 0.127	Not significant 0.264				
IC3	Significant 0.012				Not significant 0.368		
IC4	Significant <0.001				Not significant 0.138		

IC5	Significant 0.013				Not significant 0.283		
FC							
MS1							Not significant 0.304
MS2							Not significant 0.323
MS3							Not significant 0.478
MS4							Not significant 0.341
MS5							Not significant 0.304

N-B = No insole - BorgInsole®; N-G = No insole - Gepsodo®; N-P = No insole - Phits®; B-G = BorgInsole® - Gespodo®; B-P = BorgInsole® - Phits®; G-P = Gespodo® - Phits®; CPDA = contralateral pelvic drop angle; HAA = hip adduction angle; KFA = knee flexion angle; SIA = shin inclination angle; FS = footstrike; FC = foot crossover; IC = initial contact; MS = midstance; TO = toe-off; DF = double float

11 Maatschappelijke outreach

11.1 Populariserende samenvatting

Helpen inlegzolen voor mijn kniepijn?

Eén van de meest voorkomende letsels bij hardlopers is het patellofemoraal pijnsyndroom (PFPS). Inlegzolen worden vaak gebruikt om deze klachten te verminderen, maar helpen deze echt?

Wat is PFPS?

Bij PFPS kan je pijn hebben in je knie of rond je knieschijf. Deze pijn neemt toe wanneer de knie wordt gebogen tijdens belasting. Het komt voornamelijk voor bij jongvolwassenen en ook meer bij vrouwen.

(1)

Verschillende factoren spelen een rol bij de ontwikkeling van PFPS. Deze factoren beïnvloeden elkaar en zijn ook individueel verschillend. Vaak is het door een snelle toename van de hoeveelheid training of belasting. Een slechte looptechniek en verminderde spierkracht van bepaalde spieren kunnen ook bijdragen tot de ontwikkeling van PFPS. Het risico is het grootst gedurende de eerste jaren dat je loopt en is ook groter als je de klachten al eens hebt gehad.

Welke impact hebben inlegzolen?

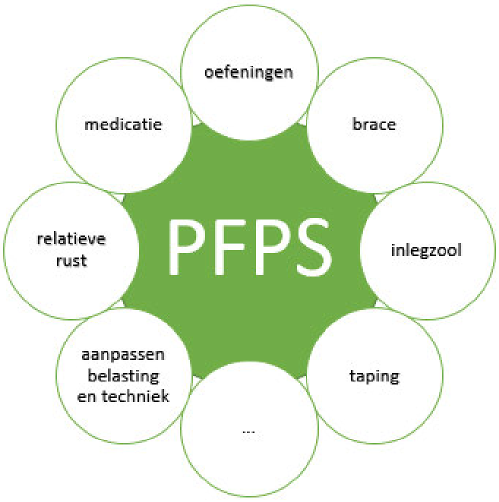
Inlegzolen kunnen op verschillende manieren helpen, ze beïnvloeden onder andere de looptechniek. De looptechniek bij mensen met deze knieklachten verschilt van mensen die geen klachten hebben. Zo gaat bijvoorbeeld het bekken meer zakken. De loopsnelheid heeft ook een effect op bepaalde onderdelen van de looptechniek en de verschillende gewrichten beïnvloeden elkaar. Zo beïnvloedt de bekkenkanteling de mate waarin de heupen en knieën worden geplooid, die op hun beurt een invloed hebben op hoe breed de voeten van elkaar worden geplaatst. Dit kan ervoor zorgen dat weefsel wordt belast dat normaal niet wordt belast, waardoor een blessure kan ontstaan.

Na het vergelijken van vier verschillende zolen, wordt er weinig verschil gevonden in de invloed die de zolen hebben op de looptechniek. Er kunnen dus geen aanbevelingen gegeven worden over welke zool nu het beste is. Dat betekent dat je niet steeds voor de duurste zool moet kiezen om het beste effect te krijgen. Inlegzolen zijn niet ‘de’ oplossing voor kniepijn. Dit wil echter niet zeggen dat ze niet kunnen worden gebruikt als behandeling, aangezien ze wel degelijk invloed kunnen hebben op factoren die belangrijk zijn voor het ontstaan van PFPS.

11.2 Maatschappelijke meerwaarde

Lopen is goedkoop, toegankelijk en kan zowel in groep als individueel uitgeoefend worden. Lopen wint aan populariteit, waardoor ook een toename in aantal PFPS klachten wordt verwacht. Het adequaat behandelen van dit overbelastingsletsel is daardoor nog meer van belang.

Aangezien meerdere factoren zorgen voor het ontstaan van PFPS, is er vaak een combinatie van verschillende behandelingstechnieken nodig. Het belang van oefentherapie en taping in de behandeling is in eerdere literatuur al aangetoond. Tot nu is er weinig onderzoek verricht naar de rol van inlegzolen bij PFPS.



Terwijl oefentherapie als doel heeft spieren te versterken en belasting op te bouwen, willen we met het gebruik van inlegzolen grotendeels de looptechniek beïnvloeden. Een inadequate looptechniek kan de klachten in stand houden en het gebruik van inlegzolen zou daarom een meerwaarde kunnen zijn in de behandeling van PFPS. Aangezien geen groot verschil gevonden is tussen de verschillende inlegzolen kan er voor een goedkopere zool gekozen worden. Daarbovenop is het eenvoudig inlegzolen te gebruiken.

Inlegzolen kunnen nuttig zijn in de behandeling van PFPS en zijn een interessant onderwerp voor toekomstig diepgaand onderzoek.

Referentie

1. Fysiotherapie4All. Patellofemoraal Pijnsyndroom – Behandeling & Oefeningen. [Internet]. Available from: https://fysiotherapie4all.nl/aandoeningen/patellofemoraal-pijnsyndroom. [Accessed 17th of May 2023].