FACULTY OF MEDICINE AND HEALTH SCIENCES

The Characteristics Of Intrinsic Foot Musculature In Recreational Runners

A cross-sectional study

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A dissertation submitted to Ghent University in fulfilment of the requirements for the degree of Master in rehabilitation sciences and physical therapy

Academic year: 2023 - 2024

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List of abbreviations

IFM = Intrinsic foot muscles
MLA = Medial longitudinal arch
CSA = Cross sectional area
HHD = Handheld dynamometer
MMT = Manual muscle testing
FPI-6 = Foot posture index-6
YBT = Y-balance test
ND = Navicular drop
FAOS = Foot and ankle outcome score
AbdH = musculus abductor hallucis
FDB = musculus flexor digitorum brevis
FHB = musculus flexor hallucis brevis
TA = musculus tibialis anterior
NDT = Navicular drop test
CM = Centimeter
N = Newton
Kg = Kilogram
MTP = Metatarsophalangeal
IP = Interphalangeal
MM = Millimeter
PM = Posteromedial
PL = Posterolateral
ANT = Anterior

ABSTRACT

Background: It is known that intrinsic foot muscles (IFM) play an important role during running. Despite the multitude of studies on runners, running injuries and biomechanics of running, only a few studies exist on the characteristics of IFM in runners. **Objectives:** The aim of this study is to identify intrinsic foot muscles characteristics i.e. cross-sectional area (CSA), thickness, strength as well as dynamic postural balance in both runners and sedentary people and the differences between them. **Study Design:** The study design is a cross-sectional study. **Methods:** A total of 48 participants were included in this study. The running group consisted of 25 participants and the sedentary group of 23. The cross-sectional area and thickness was measured by ultrasound (Telemed Logiscan 128). Next, the strength measurements were determined by a hand-held dynamometer (HHD). Lastly, the Y-balance test (YBT) was used to determine the dynamic postural balance. IBM SPSS 29 was used to perform statistics on the obtained results. **Results:** When looking at the primary outcome measures, the YBT, the HHD strength (toe flexion, hip abduction, hip extension, knee extension), CSA and thickness of the AbdH, FDB, peronei, TA of the runners group and the sedentary group were not significantly different from each other. For the secondary outcome measures, the FPI-6 showed no different scores in the running group and the sedentary group. When looking at the ND, the running group showed no differences between the two groups. Lastly, no differences were found between the running and sedentary group for the FAOS and Baecke questionnaires. **Conclusion:** The characteristics of the IFM and other parameters were successfully obtained. Runners can be expected to score better but no significant differences were found for all parameters between the running and sedentary group. More research is needed to confirm or disprove these findings.

Keywords: Cross-sectional Study, Adults, Runners, Sedentary People, Intrinsic Foot Muscles

ABSTRACT (Dutch)

Achtergrond: Het is bekend dat intrinsieke voetspieren (IFM) een belangrijke rol spelen tijdens het hardlopen. Ondanks het grote aantal studies over lopers, loopblessures en de biomechanica van het lopen, bestaan er maar weinig studies over de kenmerken van IFM bij lopers. **Doelstellingen:** Het doel van deze studie is het identificeren van kenmerken van de intrinsieke voetspieren, d.w.z. dwarsdoorsnede (CSA), dikte, kracht alsook dynamische posturale balans bij zowel lopers als sedentaire mensen en de verschillen tussen deze groepen. **Study design:** Het studie design is een cross-sectionele studie. **Methode:** In totaal werden 48 deelnemers geïncludeerd in deze studie. De lopersgroep bestond uit 25 deelnemers en de sedentaire groep uit 23 deelnemers. De dwarsdoorsnede en dikte werden gemeten met ultrasound (Telemed Logiscan 128). Vervolgens werden de krachtmetingen bepaald met een handheld dynamometer (HHD). Tot slot werd de Y-balans test (YBT) gebruikt om de dynamische posturale balans te bepalen. IBM SPSS 29 werd gebruikt om statistieken uit te voeren op de verkregen resultaten. **Resultaten:** Bij de primaire uitkomstmaten waren de YBT, de HHD-kracht (teenflexie, heupabductie, heupextensie, knie-extensie), CSA en dikte van de AbdH, FDB, peronei, TA van de lopersgroep en de sedentaire groep niet significant verschillend van elkaar. Voor de secundaire uitkomstmaten toonde de FPI-6 geen verschillende scores in de lopersgroep en de sedentaire groep. Voor de ND vertoonde de lopersgroep geen verschillen tussen de twee groepen. Tot slot werden er geen verschillen gevonden tussen de lopersgroep en de sedentaire groep voor de FAOS- en Baecke vragenlijsten. **Conclusie:** De kenmerken van de IFM en andere parameters werden met succes verkregen. Van lopers kan worden verwacht dat ze beter scoren, maar er werden geen significante verschillen gevonden voor alle parameters tussen de lopers- en de sedentaire groep. Meer onderzoek is nodig om deze bevindingen te bevestigen of te weerleggen.

Trefwoorden: Cross-sectionele studie, Volwassenen, Lopers, Sedentairen, Intrinsieke voetspieren

1. Introduction

Running is one of the most popular free time sports activities [1].
The running growth can be partially explained by its positive health impact in terms of cardiovascular fitness improvement and stress reduction [2]. Next to its advantageous health effects, negative side effects in terms of sports injuries should also be recognized [1].

In running, the foot plays an important role. The foot forms the connection between the body and the earth [3]. During running, movement of the foot is synonymous with movement of all the bones of the lower limb [3]. The foot provides traction for movement, awareness of joint and body position for balance, and leverage for propulsion [3]. To execute these complex mechanisms foot muscles, ligaments and bones are needed.

Continuing about the foot muscles, intrinsic and extrinsic foot muscles can be distinguished. The intrinsic foot muscles (IFM) are muscles that originate and insert within the foot. Consisting of four plantar layers and the dorsal intrinsic muscles [4]. They involve the abductor hallucis (AbdH), flexor digitorum brevis (FDB), abductor digiti minimi, quadratus plantae, lumbricals, flexor digiti minimi, adductor hallucis oblique and transverse heads, flexor hallucis brevis (FHB), plantar interossei, dorsal interossei and extensor digitorum brevis [4]. The IFM are essential structures during running [5]. These muscles, which help support the medial longitudinal arch (MLA), produce forward propulsion from one stride into the next stride of the running cycle [5]. The MLA is a complex mechanical structure that must be compliant on uneven surfaces and also have sufficient stiffness to allow the foot to be an efficient propulsive organ during running gait [6]. The MLA has a unique four-layer load-sharing system consisting of the plantar fascia, plantar intrinsic muscles, plantar arch, extrinsic muscles and plantar ligaments [6]. Nilsson et al. found that the MLA is the primary shock-absorbing structure of the foot. Therefore this particular area of the foot is important for the foot function [7]. When these muscles of the foot are weak or not recruited appropriately, the proximal foundation becomes unstable and mal aligned, and abnormal movement patterns of the trunk and lower extremity may appear [4]. This may lead to a diversity of overuse lower extremity injuries [4]. The study of Garofolini et al. found that running may increase foot muscle volume, muscle cross-sectional area (CSA) and bone density, but this seems to depend on training volume and experience [8]. A stronger foot provides better loading redistribution at each step [8]. Also, greater foot muscle strength may be a beneficial adaptation in response to the repetitive impact imposed on the foot during running, which may contribute to a decreased incidence of injuries [8].

Whereas reduced strength may limit the ability to control inter-joint movements leading to increased soft tissue strain [8].

It is quite a challenge to measure the strength of these short foot muscles. Directly with a handheld dynamometer (HHD) is sometimes not accurate because the contribution of extrinsic muscles cannot be excluded [9]. Therefore, the IFM strength is measured indirectly with ultrasound by defining the CSA and thickness of the muscles. Regarding the bigger muscles, Beasley et al. established the need for muscle strength testing methods that are more precise and objective than manual muscle testing (MMT) [10]. Since then, numerous reports have been published describing the use of HHD in strength testing [10]. Therefore, strength measurement with the HHD is often used to determine the muscle strength directly and more precisely.

Another important factor that running and IFM relate to is postural balance.
The fact that we as humans are bipeds and locomote over the ground with no feet in contact (running) creates a major challenge to our balance control system [11]. If we take a closer look on the foot, Epishev et al. found that excessive tonic activity of calf and foot muscles influenced the postural balance in a positive way [12]. Postural balance is the process of maintaining the body's center of gravity within the weight support base [13]. Constant adjustment is needed, which is provided by muscle activity and joint positioning [13]. In order to maintain postural balance, detection of body movements, integration of sensory information in the central nervous system and an appropriate motor response are required [13]. Dynamic maintenance of balance and motor control involve coordinated activity by the muscle kinetic chains [13]. Better balance is strongly positively associated with an improved athletic performance and negatively associated with lower limb sports injuries [14].

Despite the multitude of studies on runners, running injuries and biomechanics of running, few studies exist on the characteristics of IFM in runners. Besides, little is known about the differences in IFM characteristics between runners and sedentary people. Therefore, this study aims to identify IFM characteristics like CSA, thickness, strength and dynamic postural balance in both runners and sedentary people and the differences between them. In addition, this study also examined strength of the lower limb, navicular drop (ND) and foot posture index (FPI-6). Also, the level of physical activity, pain, symptoms and function of the foot and ankle. The dynamic postural balance was measured by the Y-Balance Test (YBT). Next, the strength of the lower limb muscles was conducted through HHD. The level of physical activity, pain and the symptoms and function of the

foot and ankle was registered by questionnaires, the Baecke questionnaire was used to measure the physical activity and for the symptoms and function of the foot and ankle, the Foot and ankle outcome score (FAOS) questionnaire was utilized. Looking at the profile of this study, one would expect runners to score significantly better than the sedentary group for all outcome parameters.

2. Methodology

2.1 Study Design

A descriptive cross-sectional study was conducted to determine and compare IFM characteristics in runners and sedentary people.

2.2 Setting

The study took place between October 2023 and February 2024 in the labs of Ghent University on the Ghent University Hospital site. Six moments of data collection took place. The testing was conducted by at least two students and a postdoc supervisor.

2.3 Participants

2.3.1 Recruitment

A flyer with the required criteria and research question was made. The flyer was shared on various social media platforms as well as the staffing services of the University Hospital of Ghent. Also, the flyer was posted several times within the online running community (Strava). Furthermore, the researchers also personally forwarded the flyer to potentially suitable candidates. If the person met the inclusion criteria, they were invited to participate in the study.

2.3.2 Inclusion criteria

Forty-eight participants were included based on the predefined inclusion and exclusion criteria. These inclusion and exclusion criteria are listed in a table (see further). Through the inclusion and exclusion criteria, 2 groups can be distinguished, namely the sedentary group and the recreational group. The participants had to be between 18 and 55 years of age and had to have no pain or other complaints at the level of the lower limb (hip, knee, ankle, foot) at the time of testing and in the past 3 months prior to the study in order to be included in one of the 2 groups. Below the full eligibility criteria can be found **(Table 1.)**

Table 1: Eligibility criteria.

Inclusion criteria		Exclusion criteria	
Sedentary	Recreationally	Sedentary	Recreationally
18-55 years old		<18 years old and >55 years old	
No pain or complaints at the level of the lower extremities (hip, knee, ankle, foot) at the time of testing and in the past 3 months prior to the study		Pain or complaints at the level of the lower extremities (hip, knee, ankle, foot) at the test time or in the past 3 months prior to the study	
Persons who have not regularly practiced a taxing sport (running, basketball, volleyball, tennis...) in the past 12 months and still do not. (though allowed: mind sports such as chess, sedentary sports such as fishing)	Average weekly running volume of at least 15 km over the past 12 months		Runners with minimalist shoes
	No experience running barefoot or with minimalist shoes		Runners using orthopedic insoles while running

2.4 Outcome parameters

2.4.1 Foot Posture Index (FPI-6)

The FPI-6 is a six-item criterion reference tool that was developed in response to a requirement for a quick, easy and reliable method for measuring foot position in a variety of clinical settings [15]. The FPI-6 consists of six validated, criterion-based observations of the rearfoot and forefoot of a person standing in a relaxed position [15]. The scoresheet can be found in **appendix 1**. The

rearfoot was evaluated via palpation of the head of the talus, observation of the curves above and below the lateral malleoli and the extent of the inversion/eversion of the calcaneus [15]. The assessment of the forefoot consists of the bulge in the region of the talonavicular joint, the congruence of the medial longitudinal arch and the extent of abduction/adduction of the forefoot on the rearfoot [15].

In this study the assessment was done on the dominant foot of the patient by at least one investigator. A total FPI-6 score ranges from −12 to +12 [16]. A foot type is classified as a highly pronated posture with a score of 10 or greater, a pronated posture with scores of +6 to +9, normal posture with scores of 0 to +5, a supinated posture with scores of −4 to −1, or a highly supinated posture with ≤−5 [16].

2.4.2 Navicular drop (ND)

The navicular drop test (NDT) is used to evaluate the MLA. It identifies the difference in millimetres (mm) between the tuberosity height of the navicular bone in the subtalar joint in sitting and standing position **(figure 1)** [17].

The prominent part of the navicular tuberosity is marked with a line. The distance from the supporting surface (floor) is measured (A) with a ribbon meter. The result was written down in mm. Next, the patient was asked to stand up and the amount of sagittal plane excursion of the navicular tuberosity is also measured (B) with a ribbon meter.

When testing the NDT, it was important to standardize the posture of the subjects. The test subjects had their knees above their feet, lower legs perpendicular to the ground and feet hip-width apart.

In 1982, Brody et al. proposed that a ND measurement exceeding 15 mm is considered abnormal, while measurements below 10 mm are considered within the normal range. Brody's NDT assesses ND statically [18].

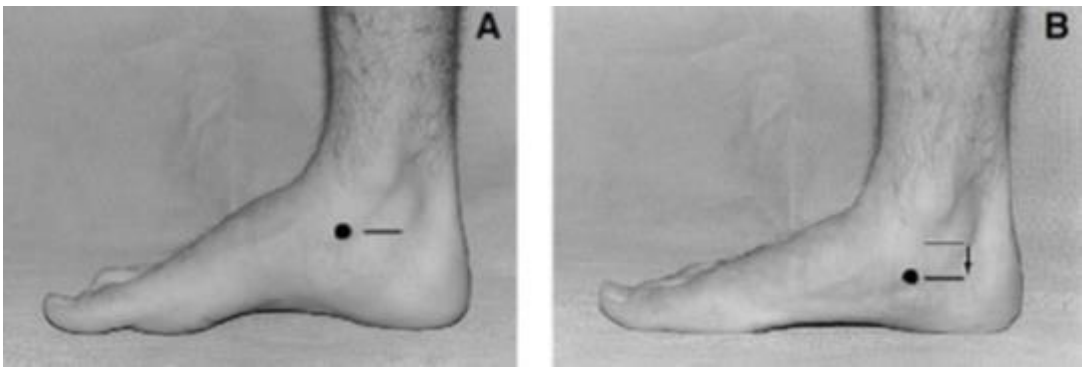

Figure 1: Navicular drop: A. Foot in sitting position B. Foot in standing position.

2.4.3 Dynamic Postural Balance: Y-balance test

The YBT, based on the Star Excursion Balance Test (SEBT) is an objective measure to determine the functional lower extremity muscle strength, the balance and uncover asymmetries between the 2 legs that may lead to an injury (**figure 2)** [19]. A difference of more than 4 centimeters (cm) reach distance between the tested legs (lower quadrant) and composed reach distances less than 94% or less than 89% of the lower limb length have been associated with an increased risk in sport-related injury [19]. The YBT shows moderate to strong evidence as a test for neuromuscular control [20].

In this study the subjects used their dominant leg as supporting leg. The non-dominant leg was used to reach in the different directions. Three directions were considered: posteromedial (PM), posterolateral (PL) and anterior (ANT) direction. Three practice trials per direction were allowed. Afterwards, measurements were taken 3 times per direction with the highest score counting. The total reach was obtained by adding up the highest scores in each direction. Next, this number was divided by the limb length and multiplied by 100 for becoming the normalized reach.

Figure 2: The Y-balance test (YBT) with anterior, posteromedial and posterolateral direction.

2.4.4 Strength: Hand-held dynamometry

Maximum isometric force of various muscles of the dominant limb–was also measured. Hip extension, hip abduction, knee extension and metatarsophalangeal flexion of the first toe were measured using a HHD. To get a fair picture of the strength, the normalized strength was calculated. This was calculated by dividing the strength in Newton (N) by the weight in kilogram (kg) for each participant.
For each movement, the participant had one practice trial, followed by three real measurements. For metatarsophalangeal (MTP) flexion, three practice attempts were allowed.
The participants are asked to gradually increase the intensity of muscle contraction for the first two seconds, after which a maximal contraction was maintained for a duration of three seconds.
The testers were allowed to motivate participants throughout the test, to ensure a maximal effort. Every repetition was standardized and did not allow any limb movement. To ensure that the measurement was isometric, a fixation strap was used for the relatively large muscles.

A detailed elaboration of the force measurement for each component is shown below.

2.4.4.1 Toe flexor strength

The muscle being examined is the intrinsic m. FHB **(figure 3)**. The subject was placed in sitting upright with bended knees [21]. The foot was positioned flat with the metatarsal heads at the table edge with the toe cantilevered off the end [21]. In this position the talocrural joint was slightly tilted towards plantar flexion. The dorsal foot was manually stabilized by the investigator [21]. Then, force was measured at the pads of the toe [21].
The procedure for assessing the strength of the toe flexors involves placing the dynamometer under the interphalangeal (IP) joint of the first toe [22]. The subject was asked to produce as much force as possible to bend the toes against the HHD [22]. Hand dynamometry allows flexion at the MTP joints and limits flexion at the IP joint because the dynamometer is placed below the IP joints [23].
The 3 practice trials were allowed because flexion of the MTP joint of the hallux is a difficult exercise in terms of motor control.

Figure 3: Strength measurement of the m. flexor hallucis brevis with handheld dynamometer.

2.4.4.2 Maximal isometric knee extension strength

The muscles being examined are the 4 heads of the m. quadriceps **(figure 4)**. The subjects were seated, upper limbs crossed in front of the trunk, knee at 60° flexion, and the HHD positioned in the anterior distal region of the tibia, 5cm proximal to the ankle joint line [24][25].

Figure 4: Strength measurement of the quadriceps muscle with handheld dynanometer.

2.4.4.3 Maximal isometric strength hip extension

The muscle being examined is the m. gluteus maximus **(figure 5)**. The subjects were lying in a prone position with the knee 90° flexed [26]. The HHD was placed just above the knee cavity under the fixation strap.

Figure 5: Strength measurement of the m. gluteus maximus with handheld dynamometer.

2.4.4.4 Maximal isometric strength hip abduction

The muscles being examined are the m. gluteus medius and minimus and the m. tensor fascia latae **(figure 6)**. The subjects are lying on the non-tested lower limb, with the tested hip at 10° abduction and the HHD was placed 5 cm proximal to the lateral region of the joint line of the knee under a fixation strap [24].

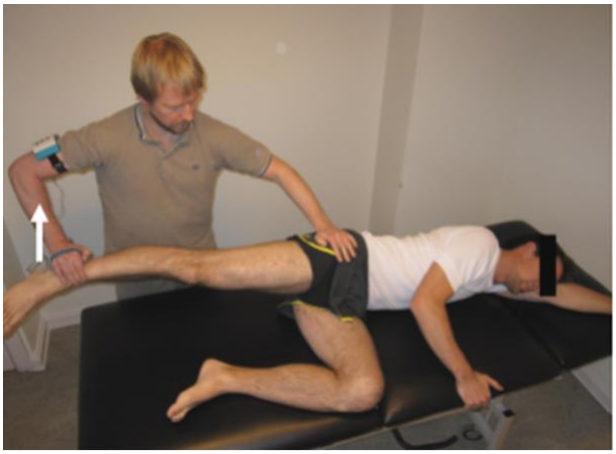

Figure 6: Strength measurement of the m. gluteus medius & minimus and m. tensor fascia latae with handheld dynamometer.

2.4.5 Ultrasound

Muscle morphology has been used to indirectly assess muscle performance due to the correlation between muscle morphology and strength capacity [27]. Using ultrasound to measure the morphology of the short foot muscles shows good reliability [27].
The Telemed Logiscan 128 (painless, non-invasive examination) was used to evaluate the thickness and CSA of the IFM. The CSA of the AbdH, FDB, peronei as well as the thickness of the AbdH, FDB, peronei and the TA was measured.

2.4.6 Questionnaires

2.4.6.1 Foot and Ankle Outcome Score (FAOS)

This questionnaire asks about the subject's opinion of the foot and ankle **(appendix 2)**. The answers give an idea of the foot and ankle symptoms and how one is able to perform everyday activities. Six subparts are questioned: symptoms, stiffness, pain, daily life functioning, functioning in leisure and sports and quality of life. A total number of 45 items are questioned. The FAOS subscale scores range from 0 to 100, with higher scores indicating better outcomes [28]. A score of 100 on a subscale indicates no symptoms or limitations in that particular area, while a score of 0 indicates extreme symptoms and limitations [28].

2.4.6.2 Baecke Questionnaire

The Baecke questionnaire was developed to assess physical activity in individuals during work and leisure time **(appendix 3)** [29][30]. The list consists of 16 questions about work, sports and leisure, where a higher score corresponds to a physically more strenuous activity [29][30]. Each question has 5 response options. Subjects had to tick the answer option closest to their reality while being honest about their physical activity time [29][30].

2.4.6.3 Self-made Questionnaire

Lastly, a short self-made questionnaire was taken from the subjects. The questionnaire was taken to obtain more background information and peculiarities from the subjects. This allowed the researchers to get a better picture of each participant. The questionnaire was administered by one

researcher and involved the following items: demographics, medical history, sports data and additional information. The self-made questionnaire can be found below (**appendix 4**).

2.5 Statistical methods

The researchers used the IBM SPSS software platform for advanced statistical analysis of the obtained results. After inserting the different data of the outcome parameters, exploratory data, such as the significance level of the Shapiro-Wilk test ($p<0.05$), the Q-Q plot and histogram was performed for each parameter. When the values were not normally distributed, the Mann-Whitney U ($p<0.05$) test was used. When the values were normally distributed, the Unpaired Student's t-test ($p<0.05$) and Levene's test ($p<0.05$) were used.

3. Results

3.1 Participants: recruitment

Eventually 48 subjects were found suitable and therefore included in this cross-sectional study. **In figure 7**, the flowchart of the recruitment process can be found.

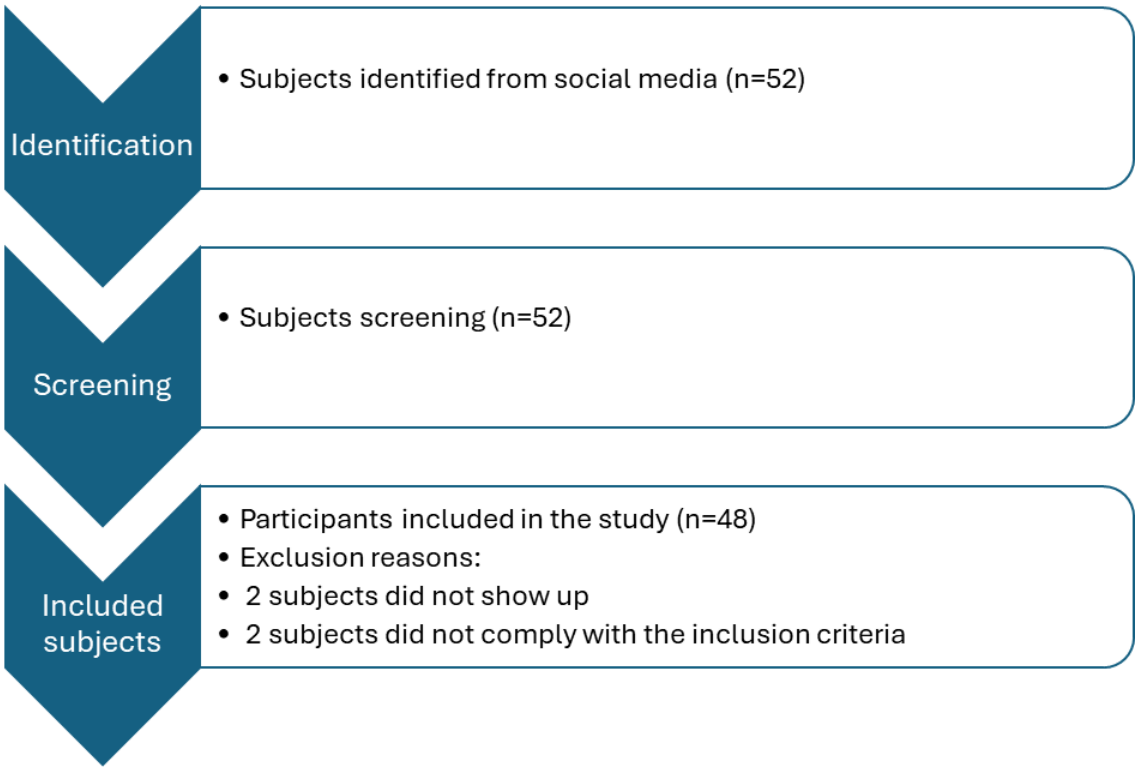

Figure 7: Flowchart of the recruitment process.

3.2 Participants: demographics

Between October 2023 and February 2024, 48 subjects aged between 19 and 52 years old were recruited for this study. Amongst them 29 men and 19 women. A total of 25 runners and 23 sedentary people were identified. The running group consisted of 18 men and 7 women. In this group the mean age was 28 ± 9.8 years. The sedentary group consisted of 11 men and 12 women. In this group the mean age was 24.2 ± 6.3 years. Further demographics of the patients can be found in **Table 2**. There was a significant difference in age ($p < 0.05$) between the two groups. When regarding the sex, weight and height ($p > 0.05$) no significant differences were found.

Table 2: Baseline Patient Demographics

Variables	Running Group (n=25)	Sedentary Group (n=23)	p Value
Sex (f/m)	7/18	12/11	0.140
Age (years)	28.0 ± 9.8 (21-52)	24.2 ± 6.3 (19-41)	0.013
Weight (kg)	71.1 ± 11.9 (50-105)	72.1 ± 14.5 (50-100)	0.779
Height (cm)	178.0 ± 9.8 (160-194)	175.5 ± 9.5 (158-193)	0.385
BMI (kg/m²)	22.3 ± 2.4 (19.0-30.0)	23.2 ± 3.1 (18.8-30.0)	/

3.3 Outcomes

First of all no significant differences were found between the two groups for all variables. Infra the non-significant differences are reported for each outcome. **Table 3** summarizes the mean scores of all outcomes. Except the FAOS questionnaire displays the median score.

3.3.1 Primary Outcome Measures

When looking at the YBT, the HHD strength (toe flexion, hip abduction, hip extension, knee extension) and CSA of the AbdH, FDB, peroneï, TA, the running and sedentary group were not significantly different from each other. Also, the thickness of the muscles above showed no significant differences. After the normalized force was calculated, again no significant difference was found.

3.3.2 Secondary Outcome Measures

The FPI-6 showed no different scores in the running group and the sedentary group. For the ND, the running group showed no differences between the two groups. Lastly, no differences were found between the running and sedentary group for the FAOS and Baecke questionnaires.

Table 3: Scores for all outcomes presented as mean, except FAOS (median).

Variables	Running Group (n=25)	Sedentary Group (n=23)	p Value
FPI-6	3.04 ± 1.37	2.39 ± 2.31	0.250
ND (mm)	4.12 ± 1.64	5.52 ± 3.13	0.064
YBT (%)	95.80 ± 7.52	92.52 ± 6.80	0.121
Toe flexion Strength (N)	101.92 ± 36.66	87.09 ± 34.90	0.159
Normalised Toe Flexion Strength (N/kg)	1.43 ± 0.43	1.22 ± 0.46	0.115
Hip Abduction Strength (N)	260.40 ± 69.95	235.26± 81.16	0.255
Normalised Hip Abduction Strength (N/kg)	3.67 ± 0.86	3.24 ± 0.83	0.087
Hip Extension Strength (N)	186.68 ± 61.15	177.87 ± 61.87	0.622
Normalised Hip Extension Strength (N/kg)	2.66 ± 0.87	2.46 ± 0.67	0.373
Knee Extension Strength (N)	373.52 ± 137.08	320.35 ± 139.83	0.191
Normalised Knee Extension Strength (N/kg)	5.18 ± 1.52	4.34 ± 1.27	0.044
AbdH CSA (mm^2)	2.31 ± 0.63	2.23 ± 0.79	0.656
FDB CSA (mm^2)	2.41 ± 0.54	2.16 ± 0.46	0.084
Peroneï CSA (mm^2)	4.07 ± 0.81	4.049 ± 0.741	0.921
AbdH Thickness (mm)	1.17 ± 0.26	1.08 ± 0.26	0.242
FDB Thickness (mm)	0.94 ± 0.19	0.91 ± 0.17	0.602
Peronei	1.60 ± 0.25	1.51 ± 0.23	0.186

Thickness (mm)			
TA Thickness (mm)	2.26 ± 0.34	2.27 ± 0.24	0.974
FAOS Questionnaire (%)	98.21	98.21	0.676
Baecke Questionnaire	8.34 ± 1.44	8.14 ± 1.50	0.642

4 Discussion

The aim of this study was to examine the characteristics of IFM in runners and sedentary people and the differences between them. The dynamic postural balance, CSA and thickness of the IFM and strength measurements of the lower limb were the primary outcomes of this study. Furthermore the FPI-6, ND, FAOS and Baecke questionnaire were incorporated as secondary outcome measures. For all outcome measures, no significant differences were found between the two groups. This disproves the hypothesis that runners would score better for each outcome parameter. Perhaps, the group characteristics may not be different enough to see significant results in all the outcome measures. One explanation can be that, regardless of one was a runner or sedentarian, they have either a sedentary or physical occupation. Also, the amount of leisure time and its fulfillment can play a role. Another explanation is that the sedentary group are sedentary in terms of running rather than in general since they walk, swim, go to the gym, ride horses etc.

Although this study found no significant differences in dynamic postural balance. Some studies claimed that physically active people have a better postural balance than sedentary people [31][32]. Regardless of these constraints, an athlete must preserve whole-body postural control to maintain their running speed. Wyatt et al showed that postural control plays an important role in maintaining speed when running [33]. Also, postural control plays an important role in maintaining body center of gravity control in turns when running [33]. In addition, impairment of dynamic postural control is associated with a higher risk for non-contact injuries [34]. These cases from the literature prove that dynamic postural control is an important parameter for runners. They also suggested that the morphology of foot muscles plays an important role in balance performance [35]. Therefore, strengthening the IFM may be an effective way to improve balance [35]. This leads directly to the following outcome: strength. The strength outcomes in this study were not significantly different in the running and sedentary group. On the other hand, there is very limited

evidence indicating that running is associated with increased foot muscle size [36]. Based on the limited evidence available, there is an indication that IFM strength and muscle size may increase with running, but this depends on the type of footwear and associated biomechanical changes [36]. A stronger foot can better control the redistribution of load with each step, whereas reduced strength can limit the ability to control movement between joints, which can lead to increased soft tissue strain; therefore, increased foot strength may be a beneficial adaptation in response to repetitive loading of the foot during running, which may contribute to a decreased incidence of injury [36]. Not only can it prevent injuries, but the literature also shows that strong intrinsic foot muscles have a beneficial impact on biomechanics during running and consequently can improve running performance [37]. From this, we can deduce that training the IFM could be an important component in preventing injuries in runners. Consequently, training the IFM should be a regular part in the training schedule of runners. Another explanation for obtaining non-significant results in terms of IFM strength may be because it is difficult to measure IFM strength in a direct way. It can be done directly, but this requires a lot of motor control from the test subjects. Also, the contribution of extrinsic muscles cannot be excluded when testing the strength of the IFM with HHD [38]. Therefore, it was opted to measure it in an indirect way via ultrasound, which is used as the gold standard. This could explain why no difference was found between the 2 groups. Unver et al. Found that a 6-week short foot exercise program was effective to decrease ND, enhancing foot posture, reducing foot pain and disability, and increasing plantar force in midfoot [39]. From this it can be assumed that IFM and their strength play an important role for the foot posture and the ND. This study showed no significant differences between the two groups in FPI. An important factor is that these findings were obtained at rest, with no exercise-induced fatigue. A study of Galloso-Lagos et al. found a significant difference in foot posture in recreational runners at baseline and after a running session [40]. During a certain period of running the foot becomes more pronated [40][41]. But considering our study, this may be temporary. More research is needed for the permanent state of the foot posture of runners and sedentary people. Lastly, no significant differences were found for either the FAOS or Baecke questionnaire. Meaning the amount of physical activity and the opinion on their foot and ankle did not differ enough. One of the main reasons why no significant results were found for this outcome parameter was the inclusion criteria of the 2 groups. Recreational runners were sought on the one hand and sedentary individuals on the other. Studying the Baecke questionnaire, these sedentary individuals indeed do not appear to run, but often they have a taxing occupation or hobby. We can also infer this from the fact that the Baecke questionnaire was not significantly different between the two groups. In the end, these sedentary individuals turn out not to be as sedentary as originally thought.

Limitations

As already indicated, the inclusion criteria in this study are a limitation. The sedentary group turned out not to be so sedentary after all. What might have been a better solution would have been for the test subjects to first complete the FAOS and Baecke questionnaire before the testing moments and only then would a decision be made whether the person could participate in the study. This could be a point of improvement for future research.

One of the reasons why no significant differences were found may also be due to the fact that some tests are subjective such as the FPI-6. This test collection, as mentioned earlier in the methods, is done by scoring based on foot type. However, there is no objective data available here, so this is purely based on subjective opinion of the researcher.

Another explanation why there are no significant differences between the runner group and the sedentary group may be because the ages were not well balanced. In the results, there is a significant difference between the ages of the 2 groups. In the sedentary group, there were mainly young 20-somethings and in the runners' group, they were mainly 30-40-year-olds. This may influence the test results to some extent.

Also, there may have been a difference in the administration of the tests between the different investigators which may have made some test results less reliable. For example, with HHD, the results may be less reliable as too much may be pushed back by the examiner resulting in a higher value. On the other hand, the literature says that HHD reliability for knee flexion, extension and hip strength is reliable [42][43]. Especially for the full lower limb, HHD proves to be a reliable source for isometric muscle strength testing [44]. For the knee extensors, peak forces are underestimated by 32% though [44]. It should be kept in mind that in reality there could be larger peak forces present than the figures that were recorded.

The next limitation of this study could be that it looked at recreational runners rather than elite runners. This study focused specifically on recreational runners so there might not have been significant differences when compared to sedentary people. With elite runners, this might be true as they often train more intensively and for longer durations so you might expect them to develop better muscle strength of the IFM to run more efficiently. As a result, postural control in elite runners

will also be better as they train longer and run at higher speeds which means the muscles of their postural system are trained better.

Lastly, this study was a cross-sectional study. This has the limitation that it is about a snapshot and no changes over time are observed. As a result, these studies are subject to bias including selection bias, information bias and confounding.

Conclusion

Although runners were hypothesized to score better, no significant differences were found for all outcome measures between the running and sedentary group. However, more research is needed to confirm or disprove the findings of this study.

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Populariserende samenvatting van het onderzoek

The Characteristics of Intrinsic Foot Musculature in Recreational Runners

Populariserende samenvatting

Hardlopen is een van de populairste sporten die men beoefent in de vrije tijd. De toename in lopers kan gedeeltelijk worden verklaard door de positieve gezondheidseffecten zoals een betere cardiovasculaire conditie en vermindering van stress. Naast de gunstige gezondheidseffecten moeten ook de mogelijks negatieve effecten zoals sportblessures worden erkend.

In ons onderzoek hebben we personen die lopen en personen die weinig tot geen fysieke activiteit hebben (sedentairen), geïncludeerd. Vervolgens zijn we aan de slag gegaan om de verschillen van de spierkarakteristieken aan de voetzool (intrinsieke voetspieren) tussen deze 2 groepen in kaart te brengen. In het onderzoeklabo zijn er verschillende testen afgenomen door de onderzoekers. De kracht, de omvang en dikte van de spieren werden gemeten. Ook hun evenwicht (posturale balans) werd bepaald door een balanstest.

Wat logisch klinkt en wat je misschien zou verwachten, is dat de lopers op al deze testen een betere score zouden halen. Er zijn studies die deze bevindingen ondersteunen. Hoe dan ook loste onze studie deze verwachtingen niet in. Nadat we de statistiek op onze resultaten gedaan hadden, vonden we voor alle parameters geen significante verschillen. Dit wil zeggen dat de scores op kracht, balans en de metingen van de omtrek en dikte van de spieren niet in die mate verschillen tussen de lopers- en sedentaire groep.

Er zijn verschillende manieren om de resultaten van onze studie te interpreteren. Enerzijds kan je stellen dat er nog een discrepantie is in de literatuur omtrent dit onderwerp. Is er nu geen verschil, wel een verschil of onduidelijkheid omtrent de karakteristieken van de voetspieren bij lopers en sedentaire mensen? Anderzijds heeft elke studie zijn kwaliteiten maar ook zijn beperkingen. Daarom is er in de toekomst nog meer kritisch onderzoek nodig rond deze topic.

Maatschappelijke impact en meerwaarde

The Characteristics of Intrinsic Foot Musculature in Recreational Runners

Maatschappelijke impact en meerwaarde

In dit onderzoek lag de focus op de intrinsieke voetspieren en de eigenschappen hiervan. We zijn ervan overtuigd dat de intrinsieke voetspieren een belangrijke rol zouden kunnen spelen bij preventie en behandeling van sportletsels. Toch is de huidige evidentie hiervan zeer beperkt en besteed men in de literatuur meer aandacht aan de extrinsieke voetspieren en de stabiliserende spieren hogerop in de kinetische keten. Ook de literatuur omtrent de intrinsieke voetspieren bij sedentaire personen is schaars. Met dit onderzoek hopen we een rol te spelen in de verder groeiende belangstelling van de intrinsieke voetspieren in de revalidatie.

Een belangrijke limitatie van dit onderzoek was dat bij het onderzoeken van de voetmorfologie gebruik werd gemaakt van een subjectieve meetschaal. In kader van de toekomst en de mogelijke verdere belangstelling van deze voetspieren, is het aangewezen om te investeren in onderzoek van meer betaalbare, toegankelijke en objectieve meetinstrumenten.

Proof of submission to the Ethics Committee

Afzender : Commissie voor medische ethiek

Prof. Dr. Roel De Ridder
Vakgroep Revalidatiewetenschappen
UGent

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Commissie voor medische ethiek	+32 (0)9 332 33 36	Ethisch.comite@uzgent.be
Aanvrager	**datum**	**pagina**
Valentien Spanhove	27/10/2023	1/6
Onze referentie:	**EudraCT-nr:**	**Belg. Regnr:**
ONZ-2023-0488		B6702023000620

Betreft:
Eigenschappen van intrinsieke voetmusculatuur bij lopers

Positief advies conform de wet van 7 mei 2004 betreffende experimenten op de menselijke persoon

Beste collega

De Commissie Medische Ethiek (CME) verbonden aan de Universiteit Gent (Ugent) en het Universitair Ziekenhuis Gent (UZ Gent) heeft het bovenvermelde dossier onderzocht en besproken op haar vergadering van 24/10/2023.

Na raadpleging van de bijkomende informatie en/of aangepaste documenten met betrekking tot dit dossier, is de CME van oordeel dat de voorgestelde studie, zoals beschreven in het protocol, wetenschappelijk relevant en ethisch verantwoord is.

EC geeft daarom op 25/10/2023 een gunstig advies over deze studie.

Ingediende documenten: zie bijlage 1
Ledenlijst: zie Bijlage 2
Aandachtspunten: zie Bijlage 3a

ALGEMENE DIRECTIE
Commissie voor Medische Ethiek

VOORZITTER:
Prof. dr. R. Peleman

SECRETARIS:
Dr. L. Goossens

INGANG 75
ROUTE 7522

Met vriendelijke groeten,
Prof. dr. Renaat Peleman
Voorzitter
Commissie voor Medische Ethiek U(Z) Gent

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C. Heymanslaan 10 | B 9000 Gent
www.uzgent.be

CC: FAGG
Cc: HIRUZ_CTU (Clinical Trial Center UZ Gent)

Unofficial translation in English:

Positive advice in accordance with the law of 7 May 2004 on experiments on the human person

The Ethics committee (EC) of University Ghent (Ugent) and Ghent University Hospital (UZ Gent) has examined and discussed the above mentioned dossier at its meeting of 24/10/2023.

After consulting the additional information and/or modified documents related to this dossier, the CME is of the opinion that the proposed study, as described in the protocol, is scientifically relevant and ethically justified.
EC therefore gives on 25/10/2023 a favourable opinion on this study

Submitted documents: see Annex 1
List of members: see appendix 2
Points of concern: see appendix 3b

UZ GENT
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Universitair Ziekenhuis Gent
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Bijlage 1: Documenten

Categorie: CV
- Roel De Ridder, geüpload dd. 05/09/2023 (Nederlands)

Categorie: GCP certificaat
- Roel De Ridder, dd. 16/06/2021 (Engels)

Categorie: Gegevensverwerkingsregister
- AVG Record, dd. 05/09/2023 (Nederlands)

Categorie: Informatie- en toestemmingsformulier
- Informatie-en toestemmingsformulier, versie 1 dd. 29/09/2023 (Nederlands)

Categorie: Vragenlijsten
- Baecke vragenlijst, geüpload dd. 05/09/2023 (Nederlands)
- FAOS, geüpload dd. 05/09/2023 (Nederlands)
- Vragenlijst, versie 1 dd. 29/09/2023 (Nederlands)

Bijlage 2: Overzicht leden CME U(Z) Gent

voorzitter: Prof. dr. R. Peleman
Secretaris: Dr. L. Goossens

Effectief lid	Plaatsvervangend lid
Prof. dr. G. Van Lancker UZ Gent - klinisch farmacoloog, ♀	Prof. dr. S. Rottey UZ Gent - klinisch farmacoloog, ♀
Prof. dr. D. De Bacquer Ugent - statisticus, ♂	Prof. dr. P. Coorevits Ugent - statisticus, ♂
Dr. M. Cosyns Extern - huisarts, ♂	Dr. J. Matthys Extern - huisarts, ♂
Dr. J. Van Elsen Extern – huisarts ♂	Dr. J. Matthys Extern – huisarts, , ♂
Prof. dr. K. De Groote UZ Gent - kindercardioloog, ♀	Dr. P. De Bruyne UZ Gent - kinder gastro-enteroloog, ♀
Prof. dr. W. Notebaert UGent - psycholoog, ♂	Dhr. W. Schrauwen UGent - psycholoog, ♂
Mevr. R. Vrielynck UZ Gent - verpleegkundige, ♀	Mevr. A. Charles UZ Gent - verpleegkundige, ♀
Dhr. C. Demeestere UZ Gent - verpleegkundige, ♂	Dhr. G. De Smet UZ Gent - verpleegkundige, ♂
Apr. K. Kint UZ Gent - apotheker, ♀	Apr. L. Huys UZ Gent - apotheker, ♀
Dhr. B. Vanderhaegen UZ Gent - Ethicus, ♂	Dhr. K. Raus UZ Gent - Ethicus, ♂
Prof. dr. T. Goffin UGent - jurist, ♂	Mevr. V. Vanscheewijck UGent - jurist, ♀
Mevr. C. Van Caeneghem extern - patiëntvertegenwoordiger, ♀	Mevr. S. Degroote extern - patiëntvertegenwoordiger, ♀
Prof. dr. W. Van Biesen UZ Gent - nefroloog, ♂	Dr. A. Beyens UZ Gent - geneticus, ♀
Prof. dr. R. Peleman UZ Gent - internist en pneumoloog, ♂	Dr. L. Goossens UZ Gent - neonatoloog, ♀
Dr. T. Martens UZ Gent - hartchirurg, ♂	Dr. H. Eker UZ Gent - algemene en hepatobiliaire chirurg, ♂
Dr. L. Dhaenens UZ Gent - fertiliteitsarts, ♀	Dr. I. Dehaene UZ Gent - verloskunde, ♀
Dr. R. Van Der Looven UZ Gent - kinderrevalidatie, ♀	Dr. M. Neckebroek UZ Gent - anesthesist, ♀
Dr. E. Schoentjes UZ Gent - [kinder - jeugd]psychiater, ♂	Prof. dr. K. Dhondt UZ Gent - [kinder - jeugd]psychiater, ♀

Appendix 3a: Aandachtspunten (indien van toepassing)

De CME bevestigt te werken in overeenstemming met de ICH-GCP-principes (International Conference on Harmonization Guidelines on Good Clinical Practice), de nieuwste versie van de Verklaring van Helsinki, het Oviedo-verdrag inzake mensenrechten en biogeneeskunde en toepasselijke wet- en regelgeving.

De CME benadrukt de verantwoordelijkheid van de PI/promotor van dit onderzoek ten aanzien van de privacy van de persoons-/patiëntgegevens in contacten met patiënten, of bij het inzien van patiëntgegevens, inclusief de juiste uitvoering daarvan door collega's en studenten. De PI/promotor is verantwoordelijk voor de uitvoering van het projectvoorstel in overeenstemming met de toepasselijke wet- en regelgeving waaronder, maar niet beperkt tot, de EU-verordening 2016/679 (Algemene Verordening Gegevensbescherming), de Belgische Wet op de patiëntenrechten van 22/ 8/2002, en het beleid van de instelling waar het onderzoek wordt uitgevoerd.

De CME verwijst op haar website naar de ICH/GCP-richtlijnen en bevestigt dat van elke onderzoeker een GCP-training vereist is. Het is de verantwoordelijkheid van de hoofdonderzoeker dat elk lid van het onderzoeksteam een geldig GCP-certificaat heeft. De conformiteit van vertaalde documenten ten opzichte van de Nederlandse documenten is de verantwoordelijkheid van de opdrachtgever.

Wij vestigen uw aandacht op het feit dat de CME verwacht dat haar eerste opmerkingen ab initio in aanmerking worden genomen bij de volgende indiening door dezelfde sponsor.

Mits er een Clinical Trial Agreement is, kan de studie pas starten wanneer de Clinical Trial Agreement werd goedgekeurd en ondertekend door de CEO van het UZ Gent (en/of door een gemachtigde vertegenwoordiger van de UGent).

Studies met geneesmiddelen voor onderzoek en bepaalde studies met "medical devices" dienen door de klant (PI of sponsor) te worden ingediend bij het FAGG (Federaal Agentschap voor Geneesmiddelen en Gezondheidsproducten).

Studies met geneesmiddelen voor onderzoek mogen enkel uitgevoerd worden op voorwaarde dat de minister (FAGG) geen bezwaar maakt binnen de wettelijke termijnen zoals beschreven in art. 13 van de Belgische wet van 7/5/2004 betreffende experimenten op de menselijke persoon en in art. 21 van de Belgische wet van 7/05/2017 betreffende klinische proeven met geneesmiddelen voor menselijk gebruik.

Bepaalde onderzoeken met medische hulpmiddelen vallen ook onder wettelijke termijnen (KB van 17/3/2009). Raadpleeg de website van het FAGG voor meer informatie: www.fagg-afmps.be .

Onderzoek op embryo's in vitro valt onder de wet van 11 mei 2003. Alvorens het onderzoeksproject kan starten, vereist dergelijk onderzoek ook een positief advies van het Federaal Comité voor medisch en wetenschappelijk onderzoek op embryo's in vitro.

Gelieve rekening te houden met de reglementen van het ziekenhuis inzake weefselbeheer en de reglementen van de wet van 19 december 2008.

Dit gunstige advies van de CME houdt niet in dat zij de geplande studie op zich neemt. U blijft verantwoordelijk voor het onderzoek. Daarnaast dient u ervoor te zorgen dat uw mening als betrokken onderzoeker wordt weergegeven in publicaties, rapporten voor de overheid etc. die het resultaat zijn van dit onderzoek. U wordt eraan herinnerd dat met betrekking tot klinische onderzoeken elke waargenomen ernstige gebeurtenis onmiddellijk moet worden gemeld aan de sponsor en de ethische commissie, zelfs als het oorzakelijk verband met de studie onduidelijk is.

De CME-goedkeuring die voor een specifiek project wordt gegeven, is één jaar geldig. Wij verzoeken u ons te informeren als het onderzoek niet wordt gestart of als het onderzoek niet binnen 1 jaar na goedkeuring start.

De CME bevestigt dat - in geval van belangenverstrengeling - betrokken leden niet deelnemen aan de stemming over het onderzoek.

Indien het onderzoek niet binnen een jaar wordt beëindigd, eist de ICH-GCP dat jaarlijks een voortgangsrapportage aan de CME wordt verstrekt.

Tot slot verzoeken wij u de (voortijdige of geplande) beëindiging van het onderzoek binnen de wettelijke termijnen te melden en het Clinical Study Report (CSR) aan de CME te bezorgen.

Houd er in het geval van een klinische proef (EudraCT) rekening mee dat de resultaten moeten worden gepubliceerd in het European Clinical Trial Register. Het rapport van deze resultaten kan als CSR naar de EC worden gestuurd.

Appendix 3b: Points of concern (if applicable)

The EC confirms working in accordance with the ICH-GCP principles (International Conference on Harmonization Guidelines on Good Clinical Practice), the latest version of the Declaration of Helsinki, the Oviedo Convention on Human Rights and Biomedicine and applicable laws and regulations.

The EC emphasizes the responsibility of the PI/promotor of this study concerning the privacy of the person/patient data in contacts with patients, or when viewing patient data, including the correct implementation thereof by coworkers and students. The PI/promotor is responsible for the implementation of the project proposal in accordance with applicable laws and regulations including, but not limited to, the EU regulation 2016/679 (General Data Protection Regulation), the Belgian Law on patients' rights of 22/8/2002, and the policy of the institution where the research will be carried out.

The EC refers to the ICH/GCP guidelines on its website, and confirms that a GCP-training is required from each investigator. It is the responsibility of the principal investigator that each member of the study team has a valid GCP-certificate.

The conformity of translated documents compared to the Dutch documents, is the responsibility of the sponsor.
We would like to draw your attention to the fact that the EC expects her initial comments to be taken into account ab initio at the next submission by the same sponsor.

*Provided that there is a **Clinical Trial Agreement**, the study can only start when the Clinical Trial Agreement has been approved and signed by the CEO of UZ Gent (and/or by an authorized representative of UGent).*

Studies with investigational medicinal products and certain studies with "medical devices" should be submitted by the client (PI or sponsor) to the FAMHP (Federal Agency for Medicines and Health Products).
Studies with investigational medicinal products are only allowed to be conducted, provided that the minister (FAMHP) does not state objections within legal deadlines as described in art. 13 of the Belgian law of 7/5/2004 concerning experiments on the human person and art. 21 of the Belgian law of 7/5/2017 concerning clinical trials with medicines for human use.

Certain studies using medical devices are also covered by legal deadlines (KB of 17/3/2009). Please consult the FAMHP website for more information: www.fagg-afmps.be.

Research on embryos in vitro is covered by the law of May 11, 2003. Before the research project can start, such research also requires a positive advice of the Federal Committee for medical and scientific research on embryos in vitro.

Please take into account the regulations of the hospital concerning tissue management and the regulations of the law of December 19, 2008.

This favorable advice of the EC does not imply that it will assume responsibility for the planned study. You will remain responsible for the study. In addition, you should ensure that your opinion as an involved researcher is reproduced in publications, reports for the government, etc. which are the result of this study. You are reminded that concerning clinical studies, any observed serious event needs to be reported immediately to the sponsor and the ethics committee, even if the causal relationship with the study is unclear.

The EC approval given for a specific project, is valid for one year. We request you to inform us if the study will not be initiated or if the study does not start within 1 year after approval.

The EC confirms that - in case of conflict of interest - involved members do not take part in the vote concerning the study.

*If the study will not be terminated within a year, the ICH-GCP demands that an **annual progress report** will be provided to the EC.*

*Finally, we request you to report the termination (early or planned) of the study within the legal deadlines and provide the **Clinical Study Report** (CSR) to the EC.*

In case of a clinical trial (EudraCT), please be informed that the results must be published in the European Clinical Trial Register. The report of these results can be sent to the EC as the CSR.

Appendix 1: The Foot Posture Index-6 (FPI-6) **(1/1).**

THE FOOT POSTURE INDEX©
FPI-6

Reference Sheet

The patient should stand in their relaxed stance position with double limb support. The patient should be instructed to stand still, with their arms by the side and looking straight ahead. It may be helpful to ask the patient to take several steps, marching on the spot, prior to settling into a comfortable stance position. During the assessment, it is important to ensure that the patient does not swivel to try to see what is happening for themself, as this will significantly affect the foot posture. The patient will need to stand still for approximately two minutes in total in order for the assessment to be conducted. The assessor needs to be able to move around the patient during the assessment and to have uninterrupted access to the posterior aspect of the leg and foot.

If an observation cannot be made (e.g. because of soft tissue swelling) simply miss it out and indicate on the datasheet that the item was not scored.

If there is genuine doubt about how high or low to score an item always use the more conservative score.

Rearfoot Score	**-2**	**-1**	**0**	**1**	**2**
Talar head palpation	Talar head palpable on lateral side/but not on medial side	Talar head palpable on lateral side/slightly palpable on medial side	Talar head equally palpable on lateral and medial side	Talar head slightly palpable on lateral side/ palpable on medial side	Talar head not palpable on lateral side/ but palpable on medial side
Curves above and below the malleoli	Curve below the malleolus either straight or convex	Curve below the malleolus concave, but flatter/ more shallow than the curve above the malleolus	Both infra and supra malleolar curves roughly equal	Curve below malleolus more concave than curve above malleolus	Curve below malleolus markedly more concave than curve above malleolus
Calcaneal inversion/eversion	More than an estimated 5° inverted (varus)	Between vertical and an estimated 5° inverted (varus)	Vertical	Between vertical and an estimated 5° everted (valgus)	More than an estimated 5° everted (valgus)
Forefoot Score	**-2**	**-1**	**0**	**1**	**2**
Talo-navicular congruence	Area of TNJ markedly concave	Area of TNJ slightly, but definitely concave	Area of TNJ flat	Area of TNJ bulging slightly	Area of TNJ bulging markedly
Medial arch height	Arch high and acutely angled towards the posterior end of the medial arch	Arch moderately high and slightly acute posteriorly	Arch height normal and concentrically curved	Arch lowered with some flattening in the central portion	Arch very low with severe flattening in the central portion – arch making ground contact
Forefoot abd/adduction	No lateral toes visible. Medial toes clearly visible	Medial toes clearly more visible than lateral	Medial and lateral toes equally visible	Lateral toes clearly more visible than medial	No medial toes visible. Lateral toes clearly visible

For further information, manuals and extra datasheets see: www.leeds.ac.uk/medicine/FASTER/FPI/

Appendix 2: Foot and Ankle Outcome Score (FAOS) questionnaire **(1/4).**

FAOS FOOT & ANKLE SURVEY

Today's date: _____ Date of birth: _____

Name: _____

INSTRUCTIONS: This survey asks for your view about your foot/ankle. This information will help us keep track of how you feel about your foot/ankle and how well you are able to do your usual activities.
Answer every question by ticking the appropriate box, only one box for each question. If you are unsure about how to answer a question, please give the best answer you can.

Symptoms
These questions should be answered thinking of your foot/ankle symptoms during the **last week**.

S1. Do you have swelling in your foot/ankle?

Never	Rarely	Sometimes	Often	Always
☐	☐	☐	☐	☐

S2. Do you feel grinding, hear clicking or any other type of noise when your foot/ankle moves?

Never	Rarely	Sometimes	Often	Always
☐	☐	☐	☐	☐

S3. Does your foot/ankle catch or hang up when moving?

Never	Rarely	Sometimes	Often	Always
☐	☐	☐	☐	☐

S4. Can you straighten your foot/ankle fully?

Always	Often	Sometimes	Rarely	Never
☐	☐	☐	☐	☐

S5. Can you bend your foot/ankle fully?

Always	Often	Sometimes	Rarely	Never
☐	☐	☐	☐	☐

Stiffness
The following questions concern the amount of joint stiffness you have experienced during the **last week** in your foot/ankle. Stiffness is a sensation of restriction or slowness in the ease with which you move your joints.

S6. How severe is your foot/ankle stiffness after first wakening in the morning?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

S7. How severe is your foot/ankle stiffness after sitting, lying or resting **later in the day**?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

(2/4)

Pain

P1. How often do you experience foot/ankle pain?

Never	Monthly	Weekly	Daily	Always
☐	☐	☐	☐	☐

What amount of foot/ankle pain have you experienced the **last week** during the following activities?

P2. Twisting/pivoting on your foot/ankle

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P3. Straightening foot/ankle fully

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P4. Bending foot/ankle fully

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P5. Walking on flat surface

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P6. Going up or down stairs

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P7. At night while in bed

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P8. Sitting or lying

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

P9. Standing upright

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Function, daily living

The following questions concern your physical function. By this we mean your ability to move around and to look after yourself. For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your foot/ankle.

A1. Descending stairs

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A2. Ascending stairs

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

(3/4)

For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your foot/ankle.

A3. Rising from sitting

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A4. Standing

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A5. Bending to floor/pick up an object

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A6. Walking on flat surface

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A7. Getting in/out of car

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A8. Going shopping

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A9. Putting on socks/stockings

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A10. Rising from bed

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A11. Taking off socks/stockings

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A12. Lying in bed (turning over, maintaining foot/ankle position)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A13. Getting in/out of bath

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A14. Sitting

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A15. Getting on/off toilet

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

For each of the following activities please indicate the degree of difficulty you have experienced in the **last week** due to your foot/ankle.

A16. Heavy domestic duties (moving heavy boxes, scrubbing floors, etc)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

A17. Light domestic duties (cooking, dusting, etc)

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Function, sports and recreational activities

The following questions concern your physical function when being active on a higher level. The questions should be answered thinking of what degree of difficulty you have experienced during the **last week** due to your foot/ankle.

SP1. Squatting

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP2. Running

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP3. Jumping

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP4. Twisting/pivoting on your injured foot/ankle

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

SP5. Kneeling

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Quality of Life

Q1. How often are you aware of your foot/ankle problem?

Never	Monthly	Weekly	Daily	Constantly
☐	☐	☐	☐	☐

Q2. Have you modified your life style to avoid potentially damaging activities to your foot/ankle?

Not at all	Mildly	Moderatly	Severely	Totally
☐	☐	☐	☐	☐

Q3. How much are you troubled with lack of confidence in your foot/ankle?

Not at all	Mildly	Moderately	Severely	Extremely
☐	☐	☐	☐	☐

Q4. In general, how much difficulty do you have with your foot/ankle?

None	Mild	Moderate	Severe	Extreme
☐	☐	☐	☐	☐

Thank you very much for completing all the questions in this questionnaire.

Questionnaire and User's Guide can be downloaded from: www.koos.nu

Appendix 3: Baecke questionnaire **(1/3).**

Questionnaire on physical activity (Baecke).

EXPLANATION

The following 16 questions are about physical activity during work and leisure time. Please read each question carefully and then check the box next to the answer that best suits you. There are no right or wrong answers.

Your first impression is usually the best, so don't spend too much time on each question.

1. Please check what you spend most of your time on during the week (only one answer possible)?

O Study
O Household
O Work

2. At my work, I sit...

O Never
O Rarely
O Sometimes
O Often
O Always

3. At my work, I stand...

O Never
O Rarely
O Sometimes
O Often
O Always

4. At my work, I walk...

O Never
O Rarely
O Sometimes
O Often
O Always

5. I lift heavy things at my work...

O Never
O Rarely
O Sometimes
O Often
O Always

6. After work, I feel physically exhausted...

O Very often
O Often
O Sometimes
O Rarely
O Never

(2/3)

7. At my work, I sweat...

- O Very often
- O Often
- O Sometimes
- O Rarely
- O Never

8. Compared to others of the same age, I find my work to be physically...

- O Much heavier
- O Heavier
- O As heavy
- O Lighter
- O Much lighter

9. Do you play sports (either as a member of a club or informally)?

- O Yes
- O No

If yes, what sport do you play?

_____

How much time per week do you spend on this sport?

- O Less than 1 hour
- O 1 to 2 hours
- O 2 to 3 hours
- O 3 to 4 hours
- O More than 4 hours

How many months per year do you practice this sport?

- O Less than 1 month
- O 1 to 3 months
- O 4 to 6 months
- O 7 to 9 months
- O 10 to 12 months

If you practice a second sport, what is it?

_____

How much time per week do you spend on this sport?

- O Less than 1 hour
- O 1 to 2 hours
- O 2 to 3 hours
- O 3 to 4 hours
- O More than 4 hours

How many months per year do you practice this sport?

- O Less than 1 month
- O 1 to 3 months
- O 4 to 6 months
- O 7 to 9 months
- O 10 to 12 months

(3/3)

10. Compared to others of the same age, I find that in my leisure time I am physically...

- O Much more active
- O More active
- O As active
- O Less active
- O Much less active

11. In my leisure time, I sweat...

- O Very often
- O Often
- O Sometimes
- O Rarely
- O Never

12. In my leisure time, I do sports...

- O Never
- O Rarely
- O Sometimes
- O Often
- O Always

13. In my leisure time, I watch TV...

- O Never
- O Rarely
- O Sometimes
- O Often
- O Always

14. In my leisure time, I go for a long walk...

- O Never
- O Rarely
- O Sometimes
- O Often
- O Always

15. In my leisure time, I go for a bike ride...

- O Never
- O Rarely
- O Sometimes
- O Often
- O Always

16. How long are you on foot and/or by bike on weekdays (to and from work, school, shopping, sports club, etc.)?

- O Less than 5 minutes
- O 5 to 15 minutes
- O 15 to 30 minutes
- O 30 to 45 minutes
- O More than 45 minutes

Appendix 4: Self-made questionnaire **(1/1).**

Self-made Questionnaire

1. Demographics
Age (years)?
Length (cm)?
Weight (kg)?
Dominant side (left/right)?

2. Medical History
Current complaints of hip, knee, foot?
History of lower limb and other complaints?
Surgery?
Insoles?
Leg length difference?
Brace/Tape when exercising?

3. Sports Data
Current sports activities?
For how long?
Competition (now or before)?
Frequency?
Running km/week?
Shoes (conventional, minimalistic, barefoot, …)?
Insoles or orthopedic soles?
Best time 5km (min)?
Best time 10km (min)?
Longest distance (km)?
Races in which participated?

4. Additional Information
Worksituation (student/full-time occupation/part-time occupation)?
Medication (relevant to mention)?
Other (systemic diseases, musculoskeletal abnormalities, …)?