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Abstract: The aim of this study was to compare the ground reaction forces and plantar pressure parameters between unloaded and occasional loaded gait. The ground reaction forces and plantar pressure of 60 participants were recorded during unloaded and occasional loaded gait (wearing a backpack which raises the participant´s body mass index to 30). The results indicate an overall increase of forces and plantar pressure during occasional loaded gait where the absolute values were analyzed ($p<0.05$), while the normalized values suggested a non-linear relation between backpack mass and plantar pressure increases, where the medial midfoot and toes were more required while the lateral rearfoot was less during loaded gait ($p<0.05$). Also, during loaded gait the magnitude of impact and propulsive forces decreased and the shear forces increased more than proportion of the load. These data suggest a different pattern of plantar pressure distribution and forces during occasional loaded when compared to unloaded gait.

Cover Letter

We, the undersigned authors of the manuscript entitled "**FORCE AND PRESSURE ANALYSIS DURING OCCASIONAL LOADED GAIT**" submitted to the Applied Ergonomics Journal for publication hereby, attest and affirm that this typescript is an original work that has not been submitted to nor published anywhere else. The authors declare that they do not have any financial or personal relationships with other people or organizations that could have inappropriately influenced this study.

Moreover, the typescript has been read and agreed by all authors.

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Highlights:

1. There is an overall increase on plantar pressure and GRF during loaded gait.
2. Plantar pressure distribution pattern is different between unloaded and loaded gait.
3. In BpG the Midfoot and Toes are most required while the lateral Rearfoot is less.
4. There seems to be a protective behavior during backpacker´s gait.

FORCE AND PRESSURE ANALYSIS DURING OCCASIONAL OVERLOAD GAIT

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1. Introduction

The backpack seems to be an appropriate way to carry load by positioning it close to the body´s center of gravity while maintaining stability (Chansirinukor et al., 2001); and it has been widely used for different purposes, students fill backpacks with books and stationeries, while hikers and militaries load them with tents and supplies (Al-Khabbaz et al., 2008). Studies analyzing physiological aspects of loaded gait indicate that the energy cost increases progressively with increases of backpack load (Knapik et al., 1996) while biomechanical aspects, by means of kinetic analysis, indicate an increase in magnitude of vertical and anterior-posterior component of ground reaction forces (GFR) (Birrell & Haslam, 2010; Birrell et al., 2007) and increase in peak lumbosacral forces (Goh et al., 1998); by means of kinematic analysis, indicate an increase of range of motion of knee and hip flexion (Attwells et al., 2006; Birrell & Haslam, 2010) and decrease of hip abduction and rotation (Birrell & Haslam, 2010), an increase of forward lean of the trunk and forward position of the head (Attwells et al., 2006; Chansirinukor et al., 2001; Hong & Cheung, 2003), increase of double support time and duration of stance phase (Birrell & Haslam, 2010) and decrease of step length (Birrell & Haslam, 2009); while by means of electromyography analysis the progressively and disproportionally increase of rectus abdominal muscle activity as the load increased (Al-Khabbaz et al., 2008) was also found.

Possibly, the alterations mentioned contribute to a significant association between the backpack weight and occurrence of back pain (Grimmer & Williams, 2000; Skaggs et al., 2006). Johnson et al. (1995) analyzed militaries during road march and it was found that as load increased, fatigue and muscle discomfort intensified, and alertness and feelings of well-being diminished. While Negrini and Carabalona (1999) by means of a cross-sectional research on school children found that 65.7% reported that carrying backpacks causes fatigue and a significant relationship was found between fatigue and back pain. Besides, the higher muscular tensions necessary to sustain these changes have been associated with injury, muscle strain and joint problems (Birrell & Haslam, 2009).

Considering kinetic analyze of backpacker's gait, little is known about where the forces are applied along the plantar surface, because on the previous studies was only used a force plate. For this reason, the inclusion of the insole pressure system in order to kinetic gait assessment seems to contribute to overall understanding of gait kinetics. The combined analysis of the horizontal and vertical component of the GRF and pressure data (distribution of GRF vertical component along the plantar surface) provide more extensive and detailed information about characteristics of the forces acting on the human body. Being possible to develop strategies, such as special insole or gait training, to minimize the impact that this occasional overload has on the locomotor system. Therefore the aim of the present study was to compare the GRF and plantar pressure parameters between unloaded and occasional loaded gait.

2. Methods

2.1. Participants

The sample was selected by convenience from university students of sport science and all of them were physically active and presented a body mass index (BMI) lower 25; besides, if they showed any traumatic-orthopedic dysfunction or some difficulties on independent gait would be excluded. Therefore 60 subjects (30 male and 30 female) with a mean age of 23.0 ± 3.7 years old, mean height of 1.68 ± 0.10 m and mean body mass of 67.8 ± 11.2 kg were enrolled in the study. This research was approved by a local ethical committee and all participants freely signed an informed consent term, based on Helsinki's declaration, which explained the purpose and the procedures of the study.

2.2. *Apparatus*

A Bertec force plate model 4060-15, operating at 1000 Hz, and an amplifier signals system model AM 6300 (Bertec Corporation, Columbus, USA), a Biopac analog-digital converter (BIOPAC System, California, USA) and a F-Scan insole pressure system (TekScan, South Boston, USA) operating at 300 Hz with about 960 pressure cells and a 0.18 mm thick insole sensor were used to kinetic gait characterization. Three digital cameras were used for visual inspection, if necessary.

2.3. *Tasks and procedures*

The participants underwent three phases: preparation, familiarization and test. In the first phase it was explained to participants the procedures which would be performed and anthropometric data (weight and height) were recorded. For each participant was calculated the weight to raise their BMI to 30, then a backpack was filled with sand and fixed at the central area of each subject's back; the load placed inside the backpack ranged from 14.1 to 30.1 kg (mean load 20.3 ± 4.4 kg). This overload was chosen because it is considered to leave the locomotor system more susceptible to injuries (Ko et al., 2010). A cuff unit measuring 98 x 64 x 29 mm with Velcro strap up was attached on the lateral malleolus region of both legs of each participant and a 9.25 mm cable linked the cuff to the VersaTek hub (F-Scan system) which was beside the walkway and connected to a computer; the cable did not cause any restriction for the gait. A pair of thin socks and, aiming to minimize the effects of different soles, a neutral shoe (ballet sneaker) with sensor insoles was provided for all participants. During the familiarization the participants walked freely (without backpack) over a 6m walkway where the force plate was embedded at the middle; in this moment the researcher identified the site where the participant should begin the gait to tramp with all surface of his right foot over the plate without altering their gait pattern. In the last phase the participants performed three valid tests without backpack (unload condition which was called control group – CG) and three valid testes with backpack (loaded condition which was called backpacker's group – BpG), where they walked with a self-selected speed looking forward and performed, at least, two steps before and after reaching the plate. The tests were considered valid when the subjects reached the plate with all the foot over it, and by means of visual inspection, did not alter their gait pattern.

2.4. Data Analysis

For the acquisition of force plate and insole pressure system data were used, respectively, the Acknowledge (BIOPAC System, California, USA) software and the F-Scan Research 6.33 (TekScan, South Boston, USA) software. The data from the force plate (three GRF components) and the insole pressure system (values of each sensor in each frame) were exported to Matlab 7.0 (MathWorks, Massachusetts, USA) software and a program was developed to the processing and calculation of the analyzed variables.

All force and pressure variables were showed in absolute values and normalized by the total weight (body mass for CG and body mass plus backpack mass for the BpG) while all time variables were normalized by the stance phase.

Considering force plate data, dependent variables were calculated to absolute ($_{Abs}$) and normalized ($_{Norm}$) values and time ($_{Time}$), respectively, for the following events: impact (first) peak ($PkVt_{I\_Abs}$, $PkVt_{I\_Norm}$ and $PkVt_{I\_Time}$), minimum between the peaks (Vt_{Min_Abs}, Vt_{Min_Norm} and Vt_{Min_Time}) and the thrust maximum (second peak) ($TMVt_{Abs}$, $TMVt_{Norm}$ and $TMVt_{Time}$) of the GRF vertical component; braking (negative) peak ($PkAP_{B\_Abs}$, $PkAP_{B\_Norm}$ and $PkAP_{B\_Time}$) and propulsive (positive) peak ($PkAP_{P\_Abs}$, $PkAP_{P\_Norm}$ and $PkAP_{P\_Time}$) of GRF anterior-posterior component; and duration of stance phase were calculated.

Considering insole pressure system data, firstly the program divided the foot into 10 regions as proposed and adapted on previous studies (Cavanagh & Ulbrecht, 1994; Gurney et al., 2008). Where the boundary between the rearfoot (RF) and midfoot (MF) was located 73% of the foot length (from toes to heel direction), being the RF divided into three equal parts (33% each); the boundary between MF and forefoot (FF) was located 45% along this length, being the MF divided into two equal parts (50% each); the FF was divided into three regions being 30% medial (first metatarsal region), 25% central (second metatarsal region) and 45% lateral (lateral metatarsals region); and the other two regions were the hallux (Hlx) and lesser toes (Toes) (2^{nd} , 3^{rd} , 4^{th} and 5^{th} toes). Therefore, dependent variables were calculated to absolute and normalized values for the sensor peak (Pk) and time of sensor peak occurrence for these 10 foot regions, respectively, for the medial RF ($PkRF_{Med\_Abs}$, $PkRF_{Med\_Norm}$ and $PkRF_{Med\_Time}$); central RF ($PkRF_{Ct\_Abs}$, $PkRF_{Ct\_Norm}$ and $PkRF_{Ct\_Time}$); lateral RF ($PkRF_{Lat\_Abs}$, $PkRF_{Lat\_Norm}$ and $PkRF_{Lat\_Time}$); medial MF ($PkMF_{Med\_Abs}$, $PkMF_{Med\_Norm}$ and $PkMF_{Med\_Time}$); lateral MF ($PkMF_{Lat\_Abs}$, $PkMF_{Lat\_Norm}$ and $PkMF_{Lat\_Time}$); medial FF ($PkFF_{Med\_Abs}$, $PkFF_{Med\_Norm}$ and $PkFF_{Med\_Time}$); central FF ($PkFF_{Ct\_Abs}$, $PkFF_{Ct\_Norm}$ and $PkFF_{Ct\_Time}$); lateral FF ($PkFF_{Lat\_Abs}$,

$PkFF_{Lat\_Norm}$ and $PkRF_{Lat\_Time}$); the hallux ($PkHlx_{Abs}$, $PkHlx_{Norm}$ and $PkHlx_{Time}$); and lesser toes ($PkToes_{Abs}$, $PkToes_{Norm}$ and $PkToes_{Time}$). The initial and final double limb stance (as percentage of stance phase) was calculated too. The program divided automated the plantar regions, however all divisions were checked by two trained researchers and, if necessary (eventually), corrected manually.

Since the insole pressure system presents good information about relative distribution of plantar forces while their absolute values have been questioned (Nicolopoulos et al., 2000; Rosenbaum & Becker, 1997; Woodburn & Helliwell, 1996) and the force plate is considered the most accurate dynamic measurements of force (Cobb & Claremont, 1995); the force plate was used to calibrate (post-test) the insole pressure system test by test.

2.5. Statistical Analysis

The intra-individual repeatability for the variables $PkFF_{ct\_Abs}$, $PkRF_{ct\_Abs}$ $PkVt_{I\_Abs}$ and duration of stance phase was verified by means of intra-class correlation coefficient (ICC). The mean of the three repetitions of each subject was computed and all the statistical procedures were performed with these mean values. The normality of the data was verified using Kolmogorov-Smirnov test and the homogeneity of the variances using Levene´s test; of 96 sets of value calculated (48 for each group), 7 of them did not present normal distribution ($PkHlx_{Abs}$ in both groups, $PkRF_{lat\_Abs}$, $PkRF_{ct\_Abs}$ and $PkRF_{med\_Anb}$ in CG, and $PkRF_{med\_Abs}$ and $PkToes_{Norm}$ in BpG) so the natural logarithmic transformation was performed and these new variables presented normal distribution, being it used to inferential statistics tests. To compare the variables between the groups (CG vs. BpG) the paired Student´s t-test was used. The significance level was $\alpha = 0.05$. The results will be presented as mean, standard deviation and confidence interval of the variables. The statistical procedures were made using SPSS (v.17; SPSS Inc, Chicago, IL, USA) software.

3. Results

The variables $PkFF_{ct\_Abs}$, $PkRF_{ct\_Abs}$, $PkVt_{I\_Abs,}$ and duration of stance phase showed ICC of 0.98 ($CI_{95\%}$ 0.97 – 0.99), 0.97 ($CI_{95\%}$ 0.95 – 0.98), 0.86 ($CI_{95\%}$ 0.78 – 0.91), 0.94 ($CI_{95\%}$ 0.90 – 0.96), respectively; indicating excellent data repeatability.

By looking to Table 1 we can see that the duration of the stance phase and the initial double limb stance were longer during BpG gait when compared to CG, while the final double limb stance did not show statistical differences.

---Table 1 ---

In the BpG 9 of 10 plantar regions showed larger absolute pressure values with $p<0.05$ when compared to CG, only on the lateral MF the differences did not have statistical significance (Figure 1A). The larger sensor peak magnitudes in BpG occurred in Hlx, RF_{Ct} and FF_{Ct} with values of 471.99 ± 260.56 kPa, 419.00 ± 117.25 kPa and 403.26 ± 121.01 kPa, respectively; and in CG occurred in Hlx, RF_{Ct} and FF_{Lat} with values of 397.39 ± 255.05 kPa, 356.72 ± 108.20 kPa and 335.41 ± 124.15 kPa, respectively. Considering the normalized values, the BpG presented larger values at PkToes and MF_{Med} while lower magnitudes at $PkFF_{Lat}$ when compared to CG (Figure 1A).

In all GRF events analyzed the BpG presented larger absolute force values with $p<0.05$ when compared to CG (Figure 1B). And when the normalized force values were analyzed, the $PkVt_{I\_Norm}$ and $PkAP_{B\_Norm}$ also showed larger values in BpG when at $TMVt_{Norm}$ the differences were observed in the opposite direction when compared to CG. The Vt_{Min_Norm} and the $PkAP_{P\_Norm}$ did not present statistical differences between groups (Figure 1B). Considering time variables (peak time), the $PkMF_{Med\_Time}$ occurred earlier while the $TMVt_{Time}$ occurred later in the CG when compared to BpG, the other time variables did not present statistical differences (Figure 1B).

--- Figure 1 ---

Considering the comparison between groups (Table 2), the larger absolute force differences were found in the following variables, respectively, at TMVt, $PkVt_I$ and Vt_{Min}; where the BpG presented the higher values. And regarding the normalized force differences, the variables that presented larger values were, respectively, at Vt_{Min} and TMVt where the BpG presented lower and at $PkAP_B$ where the BpG presented larger magnitudes when compared to CG (Table 2). Considering pressure data, larger absolute differences occurred in the medial FF, followed by the medial and central RF region; while the larger normalized differences occurred in Toes, followed by medial FF and Halux region; in all of these pressure differences the BpG showed the larger values (see Table 2).

--- Table 2 ---

4. DISCUSSION

The present study investigated the influence of occasional load in the force and pressure parameters during gait. Other studies, corroborating with our data, have already reported that during occasional loaded gait (BpG) there was an overall increase in GRF parameters (Birrell et al., 2007; Chow et al., 2005; Harman et al., 2000). On the other hand, the combined analysis of GRF parameters normalized by the total weight (body mass plus backpack mass) is scarce in the literature while the plantar pressure distribution during occasional overload gait, as far as we know, was not reported yet. Considering kinetic analysis, only the absolute values of the GRF parameters provide a limited understanding of the plantar foot forces, therefore the present study carried out an integrated analysis approach, which allowed to know not only the load supported by the human been (absolute values) but also understand the gait pattern (normalized values) and, simultaneously, the analysis of the behavior of loads in specifics plantar regions by means of insole pressure system, enabling us to acquire detailed information about change magnitudes of the plantar force and alterations of the gait characteristics promoted by carrying a backpack filled with a potential harmful load.

4.1 Rearfoot Region

Our data showed an increase of the impact forces (absolute values) in BpG, results similar to its have already been showed before (Birrell & Haslam, 2010; Birrell et al., 2007; Harman et al., 2000; Tilbury-Davis & Hooper, 1999). Birrel et al. (2007) found a linear increase between vertical force with the load applied inside the backpack suggesting that the increase in force is predominantly due to the static effect of the load rather than changes in acceleration of the system. However, the data of the present study (normalized values) indicated a non linear relation between vertical force ($PkVt_I$ and TMVt) and backpack load, which suggest a gait pattern adaptation in order to minimize the excess loading in BpG; Tilbury-Davis and Hooper (1999) corroborate with this non linear relationship, the authors observed a protective response of the locomotor system in order to mitigate a potential injury during military gait carrying backpacks weighting 20 and 40 kg.

On the other hand the $PkAP_B$ was larger (absolute and normalized), indicating that the breaking forces are potentiated (increased more than backpack mass) during occasional overload gait. Other studies corroborate with the absolute increases of the breaking force (Birrell & Haslam, 2010), while its increase even after normalized by the total weight, as far as we know, had not been reported. This anterior-posterior force helps slowing the body down during the initial part of the gait cycle (Birrell & Haslam, 2010) and, its increase, seems to be a relationship with the blister development (Knapik et al., 1997). Birrel and Haslam (2010) suggested that load carriage increases the pressure on the skin and causes more movement between the foot and the shoe through higher propulsive and braking forces, thus increasing the risk of blister occurrence; although, the authors did not assess plantar pressure as in the present study; therefore, our data support this suggestion, where during overload gait there were pressure increase in all RF regions (medial, central and lateral). So, the knowledge of this behavior ($PkAP_B$ and RF pressure increase) may contribute to understand the mechanism behind the development of this injury (blister), which is the most common related to load carriage (Knapik et al., 1997).

4.2. Midfoot Region

When we analyze the MF, seems that the medial region is very used to download during gait in the BpG, because even analyzing normalized data, larger values were found when compared to CG; Filippin et al. (2007) analyzing permanent loaded gait (obese children) found different results, where similar pressure peaks and larger contact area in medial MF were evidenced when compared to non-obese children, the authors stated that this results probably occurred due to the well-known changes in the feet of obese people, where the plantar arch becomes flat after excessive and repetitive loads; our data showed that this region (medial MF) is overloaded in BpG, being possible that this alteration be an acute adaptation promoted by occasional overload (backpack) in the gait; and, when often repeated as in permanent loaded gait (obese people), may be one of the factors that contributes to the development of the plantar arch flattening. While we analyzed the lateral MF, it was noted that during loaded gait the values were similar than those found in CG suggesting that during occasional loaded gait the medial MF is more required while the lateral MF seems to be protected. Considering Vt_{Min} the results were as expected, larger magnitudes as absolute data and similar magnitudes as the normalized data, which indicate that there is no pattern alteration in this variable during occasional loaded gait.

4.3. Forefoot Region

Considering the pressures and forces acting at the FF, as expected all variables ($TMVt_{Abs}$, $PkAP_{P\_Abs}$, $PkHlx_{Abs}$, $PkToes_{Abs}$, $PkFF_{Med\_Abs}$, $PkFF_{Ct\_Abs}$ and $PkFF_{Lat\_Abs}$) showed larger magnitudes in BpG when compared to CG; the medial FF was the region that presented the highest pressure increases when backpack was used (97.4 kPa, $CI_{95\%}$ 138.5 to 56.2) while the lowest increases occurred in lateral FF (55.3 kPa, $CI_{95\%}$ 80.8 to 29.7), indicating a higher recruitment of the medial region to support the overpressure during gait. Rather, when the data were normalized by the total weight we expected that there were no differences between groups; however, in the PkToes the values continued larger in BpG suggesting that during occasional loaded gait the toes region was more required than in the unloaded gait. Differences also were found in $TMVt_{Norm}$ where the BpG showed lesser normalized values; possibly this occurred because the backpack promotes an increase of the forward lean in response to center of mass posteriorization during gait, thus the forces needed to advance during mid-stance to toe-off phase is reduce, by means of reducing the passive momentum of the body (Birrell & Haslam, 2010).

4.4. Time Variables

In this study during BpG gait there was an increase in duration of stance phase and initial double stance when compared to CG; Singh and Koh (2009) , Hong and Brueggmann (2000) and Chow et al. (2005) found that in primary school students carrying a backpack with a percentage between 10% and 20% of the body mass there was a larger initial double stance when compared a unloaded gait, even with the participants of the present study being older and carrying a backpack heavier (32.2% of the body mass, $CI_{95\%}$ 29.5 to 34.8), our data corroborates with the previous studies mentioned. One possible explanation for this behavior is that walking with a backpack raises the combined center of mass of the backpack and the body posterior and superiorly inducing postural imbalance for static and dynamic conditions (Hong & Brueggemann, 2000; Singh & Koh, 2009), in response to it, a higher amount of double stance time may be an attempt to minimize the duration of unsteady single-limb stance (Hong & Brueggemann, 2000) and brings down the combined center of mass providing a counter effect to stabilize gait for loaded conditions (Singh & Koh, 2009). Differences also were found at $PkMF_{Med\_Time}$ and $TMVt_{Time}$ which occurred, respectively, later and earlier in BpG when compared to CG; possibly the increase of the initial double stance may promote this delay in $PkMF_{Med}$ download while the posterior shifting (Birrell & Haslam, 2010) of the center of mass may be responsible by this anticipation at the $TMVt_{Time}$.

Some possible limitation in this study should be considered: firstly, the backpack load used was not the same for all participants; we could have used, to normalize the load, the percentage of the body mass or a fixed load, however, since the locomotor system of people with BMI ≥ 30 is considered more susceptible to injuries (Ko et al., 2010), we preferred to use the BMI = 30 as overload normalization and, in order to promote a stressful load, it seems to us that it was a good way of do it. Secondly, the adopted gait speed in the present study was the one which the subjects felt more comfortable (self-selected) and such behavior can influence the characteristics of the force, on the other hand self-selected speed prevents disturbances in the gait pattern and ensure a normal walking (Pieter et al., 2009); moreover, the statistical tests used were paired, being the speed intra-individual between conditions probably very similar, thus we believe that it was the best choice. Finally, the pressure analysis only considered the vertical forces, therefore we do not know the behavior of the regional shear forces, however, as far as we know, there are very restricted devices that are able to perform this kind of analyze; alternatively, we have analyzed the anterior-posterior GRF, allowing important evidence about shear forces.

5. Conclusions

In conclusion, was observed an overall increase at the plantar pressure and GRF parameters and alterations in gait pattern during occasional loaded gait (BpG) when compared to the CG. Being the medial MF and Toes the most required during occasional loaded gait while the lateral RF less (non linear relationship between pressure and backpack mass), and considering the other regions, a linear increase occurred. Also, in order to diminish the magnitude of impact and propulsive forces was evidenced one protective behavior in the BpG; on the other hand, the shear forces have increased more than the proportion of the load, which may mean in higher susceptibility to develop blister in BpG. Therefore, seems necessary to specify adaptations in training or in material (shoe, insole, sucks, etc.) of people under occasional overload (students, hikers, military, etc.) to improve the capacity to handle the overload during gait and prevent injuries.

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Abbreviations

GRF: ground reaction forces

BMI: body mass index

CG: control group

BpG: backpack´s group

$_{Abs}$: absolute

$_{Norm}$: normalized

$_{Time}$: time of the event

Pk: peak

Vt_I: impact peak

Vt_{Min}: minimum between the peaks

TMVt: thrust maximum

$PkAP_B$: braking (negative) peak

$PkAP_P$: propulsive (positive) peak

RF: rearfoot

MF: midfoot

FF: forefoot

Hlx: hallux

Toes: 2nd , 3rd , 4th and 5th toes

$_{Med}$: medial

$_{Ct}$: central

$_{Lat}$: lateral

ICC: intra-class correlation coefficient

CI: confidence interval

SD: standard deviation

p: significant level

Titles and Legends

Figure 1A. Peak's pressure (absolute and normalized values) of each foot's region and respective time. B. Force (absolute and normalized values) and respective time of the mainly events of ground reaction force (GRF). $PkVt_I$ - impact peak of GRF vertical component; Vt_{Min} - minimum between the peaks of GRF vertical component; TMVt - thrust maximum of GRF vertical component; $PkAP_B$ – braking peak GRF anterior-posterior component; $PkAP_P$ - propulsive peak GRF anterior-posterior component; TW – total weight (in control group is equal to body weight and in backpacker's group equal body weight plus backpack weight); Y axis presents time of the events to control group (first value) and backpacker's group (second value). * - statistical difference with $p < 0.05$.

Table 1

Mean, standard deviation (SD) and significant level (p) of the stance time variables.

Table 2.

Mean, standard deviation (SD), confidence interval and significant level (p) of the differences between CG and BpG for all force and pressure variables.

Legend

The acronym of the variables can be seen in session *Data Analysis* in Methods. TW – total weight. Negative values indicate that the BpG presented larger magnitudes than CG; only in $PkAP_B$ variable the interpretation is different, where positive values indicate that the BpG presented larger magnitudes than CG.

Figure1

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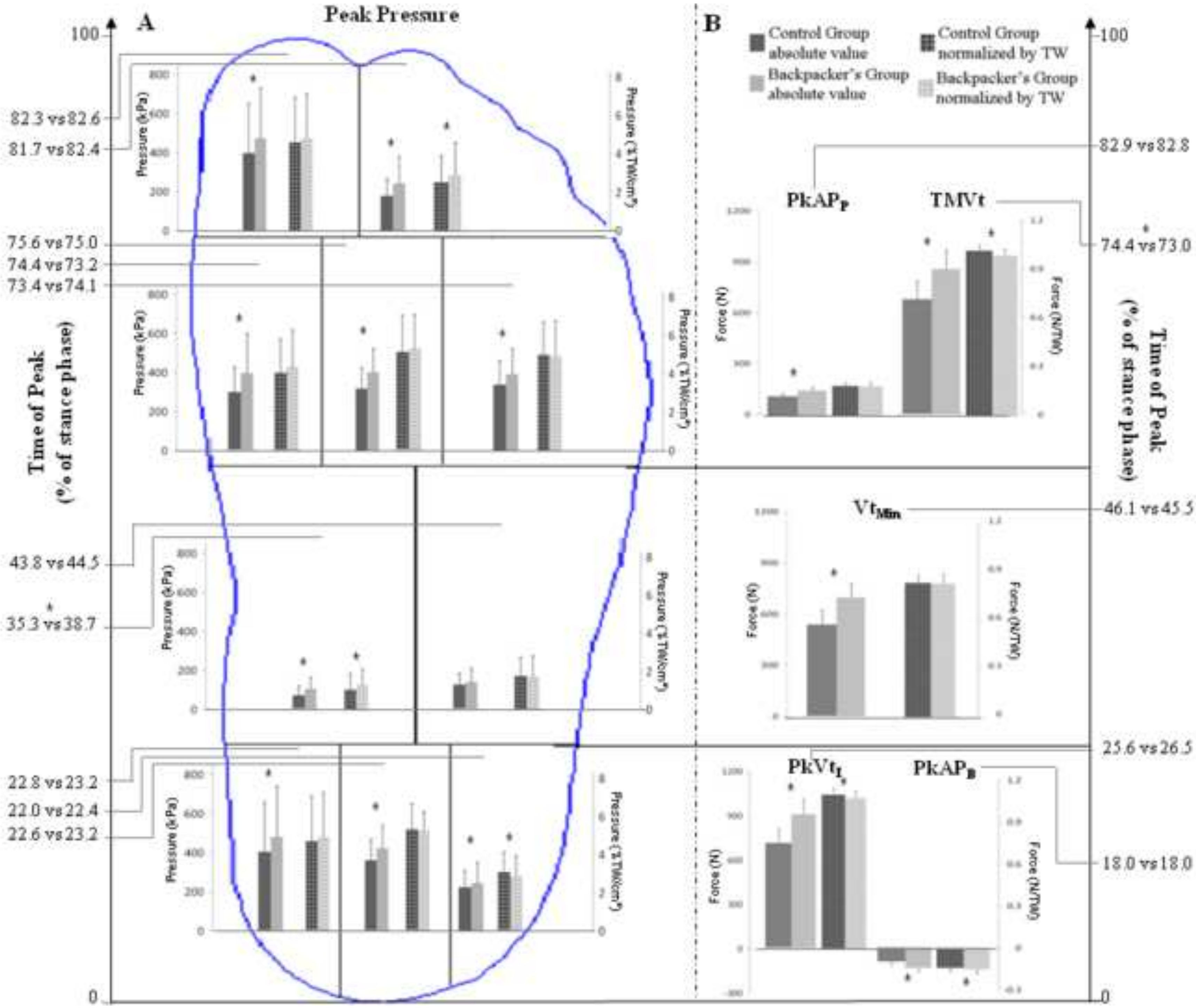

Table1

Table 1. Mean, standard deviation (SD) and significant level (*p*) of the stance time variables.

Variables	Control Group		Backpacker´s Group		
	Mean	SD	Mean	SD	*p*
Duration of stance phase (s)	0.787	0.064	0.813	0.069	0.005
Initial double limb stance (% stance phase)	22.969	4.616	24.836	5.086	0.003
Final double limb stance (% stance phase)	25.577	5.362	26.667	4.306	0.124

Table2

Table 2. Mean, standard deviation (SD), confidence interval and significant level (*p*) of the differences between CG and BpG for all force and pressure variables

Variables	ABSOLUTE DATA					NORMALIZED DATA				
	Mean		Confidence Interval			Mean		Confidence Interval		
Force	(N)	SD	Lower	Upper	*p*	(N/TW)	SD	Lower	Upper	*p*
$PkVt_I$	-177.262	74.480	-196.846	-157.679	< 0.001	0.032	0.048	0.018	0.045	< 0.001
Vt_{Min}	-159.510	56.006	-174.105	-144.915	< 0.001	0.003	0.049	-0.009	0.016	0.586
TMVt	-197.264	77.401	-217.259	-177.269	< 0.001	0.025	0.051	0.011	0.038	0.001
$PkAP_B$	39.221	20.419	33.946	44.496	< 0.001	0.014	0.024	0.007	0.020	< 0.001
$PkAP_P$	-32.577	18.204	-37.498	-27.655	< 0.001	0.002	0.023	-0.004	0.008	0.549
Pressure	(kPa)					(%TW/cm^2)				
$PkRF_{Med}$	-88.775	78.721	-110.915	-66.634	< 0.001	-0.123	0.880	-0.376	0.129	0.331
$PkR\ F_{Ct}$	-62.284	79.487	-84.413	-40.155	< 0.001	0.107	0.982	-0.172	0.387	0.443
$PkRF_{Lat}$	-21.046	61.709	-37.889	-4.202	0.015	0.204	0.662	0.018	0.390	0.032
$PkMF_{Med}$	-32.183	35.782	-41.950	-22.417	< 0.001	-0.215	0.488	-0.345	-0.086	0.002
$PkMF_{Lat}$	-14.166	52.876	-29.691	1.359	0.073	0.063	0.686	-0.136	0.262	0.529
$PkFF_{Med}$	-97.372	149.339	-138.535	-56.209	< 0.001	-0.276	1.721	-0.750	0.198	0.248
$PkFF_{Ct}$	-85.274	76.039	-107.600	-62.948	< 0.001	-0.183	1.048	-0.469	0.104	0.206
$PkFF_{Lat}$	-55.269	9.987	-80.843	-29.695	< 0.001	0.095	1.468	-0.314	0.504	0.642
PkHlx	-74.604	167.317	-119.411	-29.796	0.002	-0.241	1.616	-0.695	0.214	0.293
PkToes	-62.868	87.000	-87.088	-38.647	< 0.001	-0.363	1.164	-0.669	-0.057	0.021

The acronym of the variables can be seen in session *Data Analysis* in Methods. TW – total weight. Negative values indicate that the BpG presented larger magnitudes than CG; only in $PkAP_B$ variable the interpretation is different, where positive values indicate that the BpG presented larger magnitudes than CG.