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Behavior of temporal parameters of the ground reactive forces for the walking of postmenopausal women

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The study aimed to examine the influence of body composition and menopause characteristics on certain temporal parameters of the behavior of vertical and anteroposterior components of ground reactive forces, as well as the vertical and anteroposterior rates on the walking of postmenopausal women. The sample consisted of 67 postmenopausal women, average age 59 years. Body composition was assessed by octapolar bioimpedance and ground reactive force by the Kistler force platform. Vertical loading rate correlated positively with age ($r = 0.02$) and negatively with weight ($r = -0.33$). The relationship between the rates of vertical loading and unloading associated positively with menopause time ($r = 0.27$) but negatively with weight ($r = -0.27$). Vertical unloading rate showed a negative association with abdominal visceral adiposity ($r = -0.27$). The relationship between the times of the intermediate and final phases of the support correlated significantly with abdominal visceral adiposity ($r = 0.25$) and fat mass ($r = 0.24$). The study suggests that fat mass and abdominal visceral adiposity affect the support time, and increased abdominal visceral adiposity implies a slower pre-suspension phase during the walking of postmenopausal women. Hormone replacement therapy was shown to be an enhancer of steeper vertical loading and anteroposterior unloading and longer time in the double support phase, indicating a greater stability of postmenopausal women when walking.

Key words: *bipedal locomotion, temporal parameters, force platform, ground reactive force, menopause, visceral fat*

1. Introduction

Obesity, a modern epidemic, has become a growing problem in public health in many parts of the world. The unbalance between the increased caloric intake and restricted mobility, results in a positive energy balance materialized by the accumulation of adipose tissue. Obesity is associated to various diseases such as insulin resistance, type 2 diabetes, dyslipidemia, hypertension, cholelithiasis, some forms of cancer, fatty liver, gastro-esophageal reflux, sleep obstructive apnea, degenerative articular disease, gout, lumbar pain and polycystic ovary syndrome [13].

The regional adipose tissue distribution is equally or more important than the total amount of body fat in predicting disease, traditionally associated to obesity. Visceral obesity has been established as part of a complex phenotype, including dysfunction in adi-

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pose tissue storage and accumulation of ectopic triglycerides at various locations. The amount of abdominal fat located inside the abdominal cavity has been associated with an increased risk of comorbidities, such as type 2 diabetes, coronary heart disease, stroke, sleep apnea, hypertension, dyslipidemia, insulin resistance, inflammation and some types of cancer [23].

Aging is a process with deleterious effects on body composition. It is usually associated with the increase of total adiposity throughout adult life, with an increase of about 1% in body fat per decade, and a reduction in thin body mass after 45 years [5].

The event of menopause with the loss of ovarian follicular activity through the cessation of menstrual and ovulatory cycles by gradual reduction of estrogen, is associated to weight gain generating a magnification in the levels of overall and abdominal visceral adiposity (AVA) in women [8].

Postmenopausal state has also been associated with a higher prevalence of obesity. Lambrinoudaki et al. [9] granted the obese postmenopausal women (PW) an increased risk of 30% of developing coronary artery disease, 69% of developing ischemic stroke and 2.9% of developing venous thromboembolic stroke. Excess body weight has also been responsible for about 5% of all cancers among PW, in particular the colon and breast cancer, which can be raised up to 20%.

Estrogen deficiency has been shown to be capable of being responsible for the changes in the redistribution of body fat in PW, in particular the abdominal adiposity [8]. Espeland et al. [2] confirmed that estrogen deficiency is associated to weight gain and hormone replacement therapy (HRT) to weight loss, or to a gain significantly smaller.

Walking is an integrated motion pattern, in which any changes in some of its parameters, lead to changes in the overall pattern of the movement. When analyzing the biomechanics of the elderly walking, an increase in the step length represents an obvious risk of falling. As a strategy, they tend to decrease the speed and the size of the step increasing the time of support, to gain stability [6]. While the obese elderly shows an increase in the step length, feature developed as an adaptation to the excess weight over the knee articulation during walking [21]. However it is not known how much body fat as well as AVA can affect the temporal parameters of elderly walking, in particular the female population. Being menopause an event of great importance in the aging process for the women with all the aggravating of body fat gain and AVA, in the literature there is no specific information on the PWs walking, and it comprises the ages around 51 to 60 years old. The great majority of studies show data for an elderly population from 60 years on or middle-aged adults on a long age spectrum. Besides this diagnosis is still not clarified in the literature the effects of HRT, of nature menopause, of body fat, specifically the AVA in the temporal distribution of the parameters of PWs walking. Within this context, the current study tried to examine the relationship of fat mass (FM), AVA, age, menopause time and use of HRT, with certain temporal parameters of the behavior of vertical and anteroposterior components of the GRF as well as the vertical and anteroposterior rates during the PWs walking.

2. Materials and methods

2.1. Sample

The sample consisted of 67 PWs aged between 48 and 69 years (59.90 ± 4.21 years), being all the sample subjects part of the project "Shape Up During Menopause", whose intention is to investigate the effectiveness of an exercise program in improving cardiovascular health, physical fitness and the risk of falls in PWs. This study was conducted in accordance with the Helsinki Declaration and approved by the University of Trás-os-Montes and Alto Douro (UTAD) Ethics Committee.

All participants read and signed a consent form with information on the procedures adopted prior to study entry. The average menopause time in the sample was 28.10 years (±5.97 years). The use of HRT was reported by 56% of participants. A clinic visit to a doctor before entry, ensured the participation of PWs in fulfilling all inclusion criteria [16], such as: (1) absence of premature menopause, (2) non-existing hepatic, hematologic or renal diseases, (3) absence of cardiovascular disease (symptoms of angina in the chest, or myocardial infarction in the last 3 months) or uncontrolled hypertension (systolic blood pressure greater than 200 mmHg and diastolic one above 105 mmHg), (4) the non-use of β-blocker agents and anti-arrhythmic agents, (5) absence of musculoskeletal conditions that may impair the participation in the exercise or that may lead to the worsening of symptoms during the exercise, (6) absence of deformity or acute pain in the feet, (7) absence of acute trauma in the lower limbs, (8) no surgery in the lower extremities like prosthetic operations on the hips, knees, ankles or feet, (9) lack of leg length discrepancies, (10) absence of limiting factors like cognitive, ocular and auditive disturbances, (11) absence of peripheral neuropathy related to diabetes.

2.2. Procedures

Collections of data were carried out in the Laboratory of Physical Fitness, Exercise and Health and in the Laboratory of Biomechanics of Human Movement from the Department of Sport, Exercise and Health Sciences in UTAD by two trained evaluators and supervised by the researchers responsible for the project. The height (ALT) was measured with the stadiometer Seca 220 (Seca Corporation, Hamburg, Germany). Weight (W), FM, AVA, skeletal muscle mass (SM) were evaluated using a bioimpedance spectroscopy octopolar analyzer InBody 720 (Biospace, Seoul, Korea). The bio-impedance analyzer uses eight tactile electrodes and the manufacturer's instructions were strictly followed [1].

The cutoff points considered for FM $\geq$ 35% [12], skeletal muscle mass index (SMI) $\leq$ 28% [5], AVA $\leq$ 100 cm^2 [23]. The SMI was calculated using the formula SMMI = (SM/W) × 100 [5]. The accuracy of this method in assessing body composition is documented, some contradictory results still remains regarding AVA and % FM [3], [17]. Obesity classification was based on body mass index (BMI = weight/height^2) and validated for Portuguese PW and the cutoff point for obesity was established at 25.5 kg/m^2 [16], [18].

Measurements were taken in the morning, the participants were night fasting, following a standard methodology. After that, he doubled assessments in 10 women in order to determine the technical error (TE = $(Sd^2/2n)^{0.5}$, d is the difference between assessments and n the sample size). Technical errors of the variables were determined by two repeated measurements in a subgroup of 10 PW (height, 0.09 cm; weight, 0.06 kg; AVA, 0.46 cm^2; FM, 0.51; SM, 0.29 kg).

The data of the GRF were collected during walking in natural speed through a Kistler 9281B force platform (Kistler Instruments, Amherst, NY USA), with the recording of the force and discrete analysis of the two components of the GRF, on the anteroposterior (Y) and vertical (Z) directions, and their respective rates (Fig 1). After placed and leveled up with the ground, the platform was connected to an analogic-digital conversion system BIOPAC Systems, at an acquisition rate of 1000 Hz with the data processed by the program AcqKnowledge 3.2.6 from BIOPAC Systems. All subjects wore comfortable clothes, were barefoot and performed in a single session 10 valid trials, on a 8 meter straight and horizontal course, with the force platform installed in the middle. The obtained values were normalized relative to the weight. The walking speed was indirectly controlled through the total support time, not being considered for analysis trials with a total support time over ±5% of intra-individual average [4].

2.3. Parameterization of the GRF

The total support time Fz ($\boldsymbol{T_{total}Fz}$), the relationship among the times that certain discrete parameters of vertical and anteroposterior forces occur, as well as some variation rates of the forces Fy and Fz, were measured (Fig. 1). The support transfer phase time was measured from zero to the first maximum vertical forces Fz_1; the support intermediate phase time was measured from the first maximum vertical force Fz_1 up to the minimum vertical force Fz_2; and the time of the end of the intermediate support phase was measured from the minimum vertical force Fz_2 up to the second maximum vertical force Fz_3 (Fig. 1). Among the variables allusive to the anteroposterior component, the time of the support transfer phase, from zero up to force Fy_1; the time of support intermediate phase from force Fy_1 to force Fy_2; and the time of the end of support intermediate phase from the point Fy_2 up to the force Fy_3, were measured (Fig. 1). The relationship among the times of the vertical forces TFz_1/TFz_2, TFz_1/TFz_3, TFz_2/TFz_3 and the relationship among the time of the anteroposterior forces: Ty_1/Ty_2, Ty_1/Ty_3, Ty_2/Ty_3 were measured.

The rates of the vertical and anteroposterior component were measured according to McCrory [14], and the values of the forces were normalized for the body weight (BW). From the GRF vertical parameters, the rate of vertical load (LRv) obtained by the amplitude of the first peak of the vertical component (Fz_1) divided by the time interval in which the application of this force occurred TFz_1 (LRv = Fz_1/TFz_1) was calculated. The vertical unloading rate (ULRv) was calculated by the amplitude of the second peak of the vertical component Fz_3, divided by the total time of the GRF curve subtracted the time interval up to Fz_3 (ULRv = $Fz_3/T_{total}Fz - TFz_3$).

The rates of the anteroposterior component were obtained by indentical calculations made for the verti-

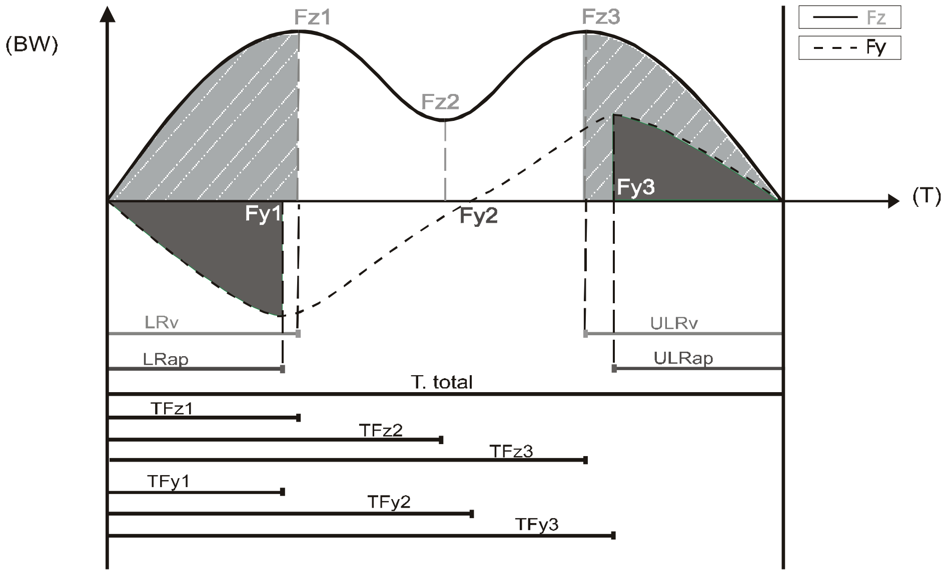

Fig. 1. Definition of the GRF parameters. Vertical force loading (LRv) and unloading (ULRv) rates. Anteroposterior force loading (LRap) and unloading (ULRap) rates. Times of vertical forces TFz_1, TFz_2, TFz_3 and anteroposterior forces TFy_1, TFy_2 and TFy_3

cal component. The anteroposterior loading rate (LRap) was calculated considering the value of the first amplitude of the force of the anteroroposteior component (Fy_1), divided by the time interval in which the application of that force (LRap = Fy_1/TFy_1) occurred. The anteroposterior unloading rate (ULRap) was calculated considering the value of the second force amplitude of the anteroposterior component (Fy_3), divided by the total time of the GRF curve after subtracting the time interval up to Fy_3 (ULRap = $Fy_3/T_{total}Fy - TFy_3$).

The calculation of the ratio between the vertical and anteroposterior force rates was obtained by dividing the vertical loading (LRv) and vertical unloading rates (ULRv), RTv = LRv/ULRv and anteroposterior loading (LRap) and anteroposterior unloading rates (ULRap), RTap = LRap/ULRap

2.4. Statistical analysis

Statistical analysis was developed with the SPSS v.19 (IBM Corp., Armonk, NY) software and 5% of statistical significance was established. The descriptive analysis indicates average ± standard deviation and the amplitude of data. The associations of biomechanical variables with body composition and menopause characteristics were assessed by Pearson's product-moment correlation. Statistical differences between different averages of biomechanical variables performed within the groups examined were tested by the Unpaired (Two Sample) *t* Test.

3. Results

The descriptive analysis is presented in Table 1, with the variables of body composition and TM. All the women had a normal muscle condition (SMI > 28%), however, 87.65% of women has high levels of AVA (≥100 cm^2), overweight and a BMI of more than 52% of postmenopausal women revealed obesity (MG ≥ 35%).

Table 1. Sample characterization ($n = 67$) mean and standard deviation

Variables	Average ± SD	Range
Age (years)	59.90 ± 4.21	48.43 – 69.49
TM (years)	10.28 ± 5.97	2.00 – 28.00
Height (cm)	156.47 ± 4.55	146.53 – 169.38
Weight (kg)	65.31 ± 9.11	44.62 – 89.04
Body Composition		
FM (kg)	23.30 ± 6.63	8.20 – 43.30
AVA (cm^2)	126.32 ± 21.84	60.64 – 171.94
BMI (kg/m^2)	26.71 ± 3.66	18.69 – 36.35
SMI (%)	35.35 ± 3.45	28.08 – 43.95

TM – Menopause time; FM – Fat mass; AVA – Abdominal visceral adiposity; IMC – Body Mass Index; SMI – Skeletal muscle mass Index.

Table 2. Descriptive analysis of the ground reactive forces ($n = 67$) mean and standard deviation

Biomechanical variables	Average ± SD	Range
Vertical temporal parameters		
$T_{Total}Fz$	0.67 ± 0.08	0.56–0.83
TFz_1/TFz_2	0.51 ± 0.04	0.43–0.68
TFz_1/TFz_3	0.32 ± 0.03	0.26–0.45
TFz_2/TFz_3	0.62 ± 0.04	0.54–0.72
LRv	6.95 ± 1.41	3.60–11.30
ULRv	6.42 ± 0.86	4.53–8.13
LRv/ULRv	1.08 ± 0.18	0.69–1.51
Anteroposterior temporal parameters		
TFy_1/TFy_2	0.31 ± .06	0.14–0.65
TFy_1/TFy_3	0.19 ± 0.03	0.10–0.38
TFy_2/TFy_3	0.61 ± 0.03	0.53–0.71
Lrap	–1.90 ± 0.44	–3.29––0.86
ULRap	2.17 ± 0.51	1.31–3.77
LRap/ULRap	–0.90 ± 0.25	–1.75––0.38

$T_{Total}Fz$ – Total time of force Fz; TFz/TFz – Relationship between the times of the forces Fz; LRv – Vertical loading rate; ULRv – Vertical unloading rate; LRv/ULRv – Relationship between the vertical loading and unloading rates; TFy/TFy – Relationship between the times of the force Fy; LRap – Anteroposterior loading rate; ULRap – Anteroposterior unloading rate; LRap/ULRap – Relationship between anteroposterior loading and unloading rates.

The descriptive analysis of biomechanical variables related to vertical and anterior-posterior temporal parameters of the GRF, is illustrated in Table 2. For the rates the same nomenclature loading (LR) and unloading (ULR) was used, the vertical direction being indicated (LRv and ULRv) and anteroposterior (LRap and ULRap). Table 3 presents the relationship between TM and body composition variables with temporal GRF, where the ratio of vertical rates showed to be sensitive to TM and weight. The age of postmenopausal women positively influenced the rate LRV unlike weight, which affected it negatively. Both the MG as the AVA affected TFz_2/TFz_3 variable, but the ULRv rate showed to be negatively influenced by the AVA. No significant associations between BMI and IMME and temporal variables of the GRF were identified.

Statistical differences between different averages of biomechanical variables performed within the groups defined according the characteristics of the menopause, such nature of menopause (natural or induced), the use of HRT and time of menopause (more than 10 years and less or equal than 10 years), were tested by the Unpaired (Two Sample) t Test. No differences were found between the two groups defined according the time of menopause. Table 4 shows only differences with statistical significance.

In the analysis of the groups of nature of menopause, the women who have natural menopause exhibit a higher ratio between the vertical rates LRv/ULRv ($p < 0.014$). In the HRT group, the PWs who use HRT had higher vertical rate LRv ($p < 0.032$) and anteroposterior rate ULRap ($p < 0.017$) and higher values in the anteroposterior component TFy_1/TFy_2 ($p < 0.026$) and TFy_1/TFy_3 ($p < 0.037$).

Table 3. Association (Pearson's product–moment correlation) of temporal parameters of GRF with menopause time and body composition

	TM (years)	Age (years)	FM (kg)	AVA (cm^2)	Weight (kg)	BMI (kg/m^2)	SMI (%)
TFz_1/TFz_2	–0.144	–0.064	0.035	0.005	0.093	0.055	0.061
TFz_1/TFz_3	–0.048	–0.039	0.210	0.178	0.237	0.207	–0.112
TFz_2/TFz_3	0.107	0.006	0.247*	0.252*	0.211	0.216	–0.229
TFy_1/TFy_2	0.056	–0.042	–0.070	–0.066	0.016	0.067	0.159
TFy_1/TFy_3	0.037	–0.076	–0.070	–0.054	0.008	0.048	0.134
TFy_2/TFy_3	–0.081	–0.101	0.003	0.033	–0.057	–0.101	–0.112
LRap	0.010	–0.120	–0.037	0.030	0.083	0.068	0.151
ULRap	–0.038	0.098	0.038	–0.082	0.058	0.007	–0.021
LRap/ULRap	–0.035	–0.73	–0.018	–0.062	0.119	0.066	0.154
LRv	0.170	0.248*	–0.212	–0.174	–0.330**	–0.236	0.054
ULRv	–0.073	0.070	–0.174	–0.276*	–0.137	–0.195	0.180
LRv/ULRv	0.275*	0.205	–0.108	0.023	–0.275*	–0.114	–0.085

*$p < 0.05$; **$p < 0.01$; TFz/TFz – Relationship between the times of the forces Fz; LRv – Vertical loading rate; ULRv – Vertical unloading rate; LRv/ULRv – Relationship between the vertical loading and unloading rates; TFy/TFy – Relationship between the times of the force Fy; LRap – Anteroposterior loading rate; ULRap – Anteroposterior unloading rate; LRap/ULRap – Relationship between anteroposterior loading and unloading rates; TM – Menopause time; FM – Fat mass; AVA – Abdominal visceral adiposity; BMI – Body Mass Index; SMI – Skeletal muscle mass index.

Table 4. Differences with statistical significance (Unipaired – Two Sample – t Test) found between the groups defined for menopause nature (natural and induced menopause) and hormone therapy (with and without hormone replacement therapy)

Temporal parameters of the GRF	Groups examined		
	Natural Menopause (n = 58) Average ±DP	Induced Menopause (n = 9) Average ±DP	p Values
LRv/ULRv	1.08 ± 0.19	1.07 ± 0.09	0.014
	Without Hormone Replacement Therapy (n = 29) Average ±DP	With Hormone Replacement Therapy (n = 38) Average ±DP	p Values
LRv	6.53 ± 1.24	7.27 ± 1.47	0.032
TFy_1/TFy_2	0.29 ± 0.05	0.32 ± 0.06	0.026
TFy_1/TFy_3	0.18 ± 0.03	0.19 ± 0.03	0.037
ULRap	2.00 ± 0.43	2.30 ± 0.53	0.017

LRv/ULRv – Relationship between the vertical loading and unloading rates; LRv – Vertical loading rate; TFy_1/TFy_2 – Relationship between the times of the force Fy_1 and Fy_2; TFy_1/TFy_3 – Relationship between the times of the force Fy_1 and Fy_3; ULRap – Anteroposterior unloading rate; Value $p < 0.05$.

4. Discussion

Through the evaluation of the walking parameters, the GRF have contributed to a better understanding of the temporal distribution of the loads placed on the foot during human movement. Over the past decades the biomechanical analysis of the walking has been pursued by many authors through the vertical measurement of GRF with its characteristic "M." shaped curve with discrete parameterizations in different points [22], [25]. In the present study, when examining the vertical and anteroposterior support time of the GRF during the walking of PWs, the curves were found to be very regular and repetitive. However, the vertical rate LR shown in Table 3, which is the parameter that describes how rapidly the vertical force increases during the transfer phase of the support from a foot to the other during walking, was shown to be more pronounced in older women (6.9 BW/s) and specifically in PWs who use HRT (7.2 BW/s), Table 4. These findings are in accordance with data published by Stacoff et al. [19], [20] who also analyzed the walking of elderly people at ground level and slope of stairs and found slightly higher values (7.8 BW/s and 7.5 BW/s) for the data tested. Liikavainio et al. [11] found much higher values on another group of elderly (8.5 BW/s), possibly explained by the difference of the instrument used to collect data. Based on the data in the current study, the group of women using HRT, showed expected results, with a more marked LRv rate during walking, when compared to healthy individuals and women not using HRT. Furthermore, results showed a significant negative effect of the weight (W) on the LRv rate (Table 3). The analysis of this datum shows that the weight negatively influences the LRv rate, in which increased weight can contribute to the prediction of a less pronounced LRv rate in PW, signaling a lower rapidity on the force increasing during the transfer phase of double support from one foot to the other during walking.

The TM is another factor influencing the temporal behavior of the support on the ground during the walking of PWs. The positive association between TM and the relationship between LRv and ULRv rates, presented in Table 3, suggests that the longer the menopause time the higher the relationship among rates will be, causing specific differences in the accommodation of external load during the walking of these women. The group of women with natural menopause also positively correlated with the relationship between the vertical rates (LRv/ULRv), suggesting that the natural menopause, in which a gradual decrease in the reduction of estrogen usually occurs, the accommodation of external loads during the walking also happens less abruptly. However, the weight was the variable that negatively correlated again with LRv/ULRv, suggesting that the increase in weight can be one of the predictors of a less heterogeneous accommodation of external loads during the walking of PW.

Older adults obese, with an average age of 68 years show marching patterns altered when compared to homologues of normal weight. They tend to have a longer support time during walking [7]. This datum seems to support the findings of the current study. The relationship between the times of the vertical forces

TFz_2/TFz_3 showed a positive relation with the FM and AVA, suggesting that the times of the intermediate phase and the final phase of support are sensitive to total fat and AVA of PW, during the walking. In addition to the combination of obesity increase with the increase in AVA, exponentially increase the risk of coronary heart disease and diabetes [23], they also positively affect the support time during the walking of PWs. Thus, by increasing the FM and the AVA these women also tend to increase the time of support during the walking.

Another fact, perhaps the most important of the study, was the association found between the vertical rate ULRv, which is the parameter of the GRF that indicates how fast the vertical force decreases during the pre-suspension phase, with the AVA (Table 3). This study can only be compared with other studies [10], [14], [19], [20], [25], which analyzed the ULRv rate during the walking. PWs with a high level of AVA (126 cm^2) was found to have a smaller vertical rate ULR (6.4 BW/s), indicating a slower unload of the load during the walking. In agreement with the study data, McCrory [14] and his collaborators who have studied subjects with an average age of 59 years who underwent surgery for hip arthroplasty, identified a reduction of the ULRv rate during the walking of these subjects of 6.5 BW/s. In another analysis, however with young subjects and post-arthroscopic reconstruction of the anterior cruciate ligament (ACL), Winiarski and Kucharska [24] also reported a significant decrease in ULRv rate (5.1 BW/s) in the group of ACL reconstruction in the first stage of therapy, registering significant increases (2% and 28%) during stages two and three, reaching final results in ULRv rate of 6.7 BW/s. The above results seem to confirm the findings of the study, which the rate ULRv of PWs with accumulation of AVA show to be very close to the rate of individuals who have suffered surgical interventions in the lower limbs. Thus, the present study found the vertical rate ULRv of PWs with accumulation of AVA, in order to be compared with the rate of other individuals who had suffered surgical interventions of high degree of complexity in the lower limbs, showing that AVA exerts significant influences on the parameter tested during the walking of PWs. This finding is strengthened when it is associated tothe results of Stacoff et al. [19], [20], who found a much higher vertical rate ULRv (9.5 BW/s and 9.0 BW/s) on the walking of healthy elderly. Therefore, the study suggests that the PWs with accumulation of AVA have greater care in the pre-suspension phase, performing a slower unloading during the walking. The present study is the first to provide data on the parameters of the vertical curve of GRF in the walking of PW, with accumulation of visceral adiposity in the abdominal region.

The GRF were not as sensitive to BMI and SMI. Therefore it was not possible to determine the associations between BMI, SMI and GRF and the influence on the temporal vertical and anteroposterior parameters. When compared to the TM group (≤10 years and >10 years), there was no statistically significant correlation with the temporal parameters of the GRF.

In the group of PW who use HRT (56%), the rate Lrap (2.3 BW/s), found to be normal. This GRF parameter indicates how quickly the anteroposterior force decreases during the pre-suspension phase during the walking. Messier et al. [15] presented a ULRap rate very close to normal elderly subjects (2.1 BW/s). Once the anteroposterior component is an important parameter to consider due to the relation with the possibility of sliding resulting from falls, the use of HRT showed to be a good predictor for the prevention of accidents because PWs without TSH presented not so low values, but significantly lower than the users of the therapy. Therefore, our study indicates that use of HRT is a factor that positively influences the GRF, specially the anteroposterior pre-suspension phase during the walking of those women.

The HRT, in addition to influencing positively the anteroposterior pre-suspension phase it also influences the relationship between TFy_1/TFy_2 and TFy_1/TFy_3. PWs without the use of HRT showed a relationship between the time of the double support transfer phase of the anteroposterior parameter and the time of the support intermediate phase (TFy_1/TFy_2), and the support final phase (TFy_1/TFy_3) less favorable than the users of the therapy (0.29 and 0.32 BW/s, 0.18 and 0.19 BW/s). These data, even with slight differences but with statistically significance may be indicative that the PWs, without the use of HRT, spend a lesser time for the double support transfer phase. The literature has shown that the elderly tend to have an increased time in the double support transfer phase, as a strategy to gain stability during the walking [6]. Thus, the study indicates that the PWs without the use of HRT concur to a greater instability during the walking.

This study should be interpreted in light of some limitations. The muscle condition was not considered due to the absence of sarcopenic PWs and a small percentage of obese participants in the sample. These limitations may be due to the fact that the present study population is relatively young, with representative levels of physical activity and estrogen.

5. Conclusion

The PWs, and especially the HRT users, tend to have a greater rapidity on the increase of the vertical load during the support transfer phase, sometimes associated with a decrease in the duration of this phase. However, PWs with more weight tend to be more cautious during this phase, signaling a longer time in the support transfer phase. The natural menopause showed to be a positive factor in the distribution of external loads LRv/ULRv the same way as the TM showed to influence the accommodation of loads with their specific differences. Weight is a factor that negatively influences the accommodation of loads in LRv/ULRv. The increase of FM and AVA shows the relation between the support intermediate and final phases, making the support time more robust during the walking. The accumulation of AVA also caused a decrease in the speed of the vertical load ULRv decrease during the pre-suspension, phase signaling a slower and more cautious unloading of PWs during the walking. In the anteroposterior parameter, the lack of HRT also caused a decrease in the speed of load ULRap decrease during the pre-suspension phase, suggesting a slower unloading. The decrease of the vertical and anteroposterior unloading rates is associated with reduced mobility of PWs. Regarding the relationship between the time of weight acceptance with the support intermediate and final phases, the lack of HRT showed to be unfavorable, signaling a lesser spending of time for the double support transfer phase, concurring the PW without HRT for a greater instability during the walking.

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