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Analysis of gait efficiency and characterization using inertial sensors in treadmill: people with multiple sclerosis

Sara Isabel Martins Cabral

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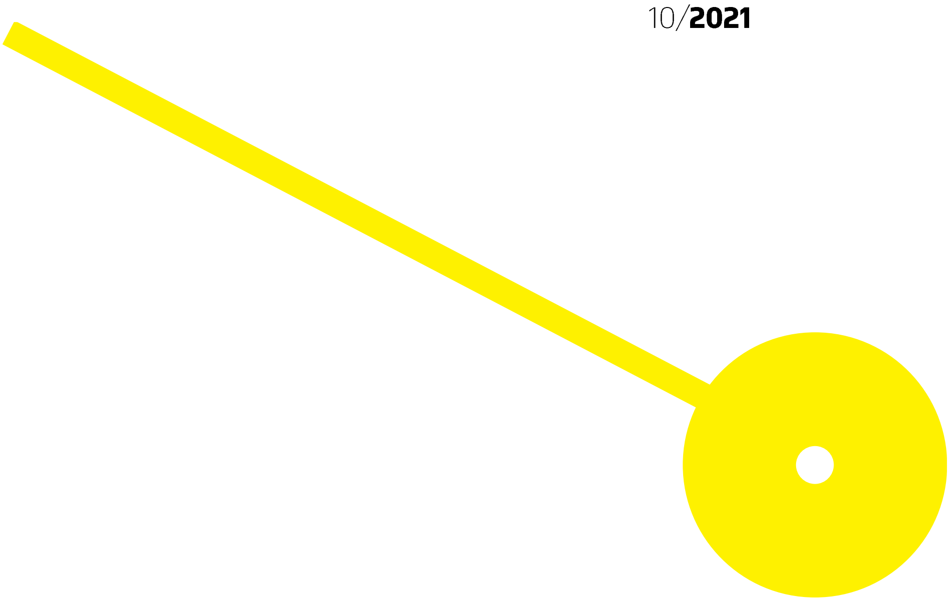

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Analysis of gait efficiency and characterization using inertial sensors in treadmill: people with multiple sclerosis

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Resumo

Introdução: A Esclerose Múltipla é uma doença autoimune, com sintomatologia heterogénea e imprevisível, de onde a afeção da marcha se destaca. **Objetivos**: Como objetivos destacam-se a exploração da utilização de sensores inerciais de modo a detetar alterações mínimas na marcha em portadores de Esclerose Múltipla, através da exploração da relação das variáveis espaço-temporais com perceção subjetiva de esforço, bem como da sua compração com valores de referência. Foi analisada a variabilidade em condições de fadiga nesta amostra. **Metodologia**: O estudo de caso controle observacional, incluindo 11 participantes, envolveu caminhar durante seis minutos numa passadeira elétrica, utilizando 15 sensores inerciais para registar 19 variáveis espaço-temporais bem como perceção subjetiva de esforço. Foram utilizados os testes de Shapiro-Wilk, correlação de Spearman, teste-T para uma amostra e Wilcoxon de acordo com a distribuição das variáveis. Valor de significância de $P < .05$. **Resultados**: Só duas variáveis apresentaram valores excelente de consistência. Não foram encontradas correlações entre variáveis espaço-temporais e perceção subjetiva de de esforço. Foram encontradas diferenças entre as variáveis espaço-temporais e os seus valores de referências. **Conclusão**: Os sensores inerciais são uma ferramenta eficiente para detetar alterações mínimas nesta amostra.

Palavras-chave: Variáveis espaço-temporais; prova de marcha de seis minutos; controlo postural; gerador de padrão central

Abstract

Introduction: Multiple Sclerosis (MS) is an autoimmune disease, with heterogeneous and unpredictable symptoms, from which the gait disorder stands out. **Objectives**: The main aim of this study was to explore whether the Inertial Measurement Units (IMUs) allow to identify suble changes in gait parameters in people with Multiple Sclerosis (pwMS) by trying to predict the relationship of the spatiotemporal variables with Modified Borg Scale (MBS) values. It was assessed minimal spatiotemporal abnormalities with reference values. It was analyzed MS variability in a fatigued condition. **Methodology**: An observational case control study, included 11 pwMS, while walking for six minutes in a Treadmill, using 15 IMUs to measure 19 spatiotemporal variables and MBS values. It was carried out Shapiro-Wilk test, Spearman's rank correlation coefficient, one sample T-test and Wilcoxon signed rank test according to the metrics distribution. The level of significance was set at $P < .05$. **Results**: We found only excellent reliability for two spatiotemporal variables, no correlation between MBS and spatiotemporal variables, and suble differences between IMUs and their reference values. **Conclusion**: IMUs is a effective instrument to identify suble changes linked to spatiotemporal variables in a group of minimal walking impaired pwMS relapsing-remitting.

Keywords: Spatiotemporal variables; six minutes walking test; postural control; central pattern generator

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List of abbreviations

MS – Multiple Sclerosis

CNS - central nervous system

pwMS - people with MS

HAI - Hauser Ambulation Index

6MWT – six minutes walking test

MBS – modified Borg scale

IMUs - Inertial measurement units

SDI - Strap-Down Integration

SSWS - self-selected walking speed

3D – three-dimensional

SPEM – Socieade Portuguesa de Esclerose Múltipla

IMUw - IMU wirelessly

CPG - central pattern generator

MRI - magnetic resonance imaging

1. Introduction

Multiple Sclerosis (MS) is an chronic autoimmune progressive disease of the central nervous system (CNS) affecting approximately 2,3 million people worldwide, being the most common non-traumatic cause of disability in young and middle-aged adults (Angelini et al., 2019; Cameron & Nilsagard, 2018; Filli et al., 2018; Kalron et al., 2013; Khan et al., 2007; Lazibat et al., 2018; Thompson et al., 2018).

Symptoms of MS result from inflammation, demyelination and neurodegeneration, which is why they are heterogeneous, unpredictable and variable over time, highlighting the presence of fatigue, cognitive and somatosensory changes, altered sensorimotor responses, muscle asymmetry, and spasticity, leading to changes in daily functional activities, from which the gait disorder stands out (Chung et al., 2016; Craig et al., 2017; Crenshaw et al., 2006; Filli et al., 2018; Heesen et al., 2008; Huisinga et al., 2013; Kalron et al., 2013; Kalron & Frid, 2015; Swinnen et al., 2012; Thompson et al., 2018; A Vienne-Jumeau et al., 2019; Aliénor Vienne-Jumeau et al., 2020).

Gait is referred by people with MS (pwMS) as the one that most interferes with their autonomy and participation, conditioning the interaction with the environment that surrounds them, cronstaining their quality of life (Angelini et al., 2019; Craig et al., 2017; Filli et al., 2018; Kalron et al., 2013; Kalron & Frid, 2015; Roldán-Jiménez et al., 2015; Socie et al., 2013; Swinnen et al., 2012; Thompson et al., 2018; Weller et al., 2020).

Furthermore, through its performance, it is possible to monitor the severity and progression of the highlighted clinical condition (Filli et al., 2018; Moon et al., 2017; Socie et al., 2013; A Vienne-Jumeau et al., 2019; Weller et al., 2020).

There is growing evidence that variability in spatiotemporal parameters of walking provides unique information on walking and the health of the neuromuscular system, once this can provide information about the sensorimotor control systems responsible for governing movement and postural control during gait (Brach et al., 2007; Craig et al., 2017; Hausdorff, 2005; Kaipust et al., 2012; Myers et al., 2010; Socie et al., 2014; Sosnoff et al., 2012). Nowadays, it has been demonstrated that pwMS who have minimal disability have elevated gait variability compared with healthy controls (Craig et al., 2017; Sosnoff et al., 2012) and that gait variability scales with disability (Kalron, 2016; Socie et al., 2013).

The measurement of gait and motor control in pwMS are usually assessed in routine clinical practice using rating scales (e.g. Hauser Ambulation Index (HAI)) or timed tests (e.g. six minutes walking test (6MWT)), as they are accessible and easy to carry on, and often combined with other self-reported scales (e.g. Modified Borg Scale (MBS)). However, these tools suffer from some limitations as they have a relatively limited sensitivity to changes and can not provide objective measures of the different components and characteristics of the task, namely thy can only describe *how* the performance is possibly (Angelini et al., 2019; Bethoux & Bennett, 2011; G. A.

Borg, 1982; Chung et al., 2016; Kalron et al., 2013) . This makes it difficult to detect possible modifications in minimally impaired pwMS (Liparoti et al., 2019; Pau et al., 2017; Spain et al., 2012).

Instrumental methods (e.g. treadmill, inertial measurement units (IMUs)), may partly overcome these limitations by providing additional quantitative information, thus enabling exposure of subtle variations usually invisible to the naked eye (Angelini et al., 2019; A Vienne-Jumeau et al., 2019).

In particular, IMUs hold several advantages for behaviour tracking 'in the wild' (e.g., free-living conditions). IMUs offer low cost, highly portable, robust and inconspicuous tools that are better suited to measure daily life activities in unconstrained environments. Thus, IMUs may play a key role in translating the effect of biomechanical research to the everyday activities of health and pathological populations (Angelini et al., 2019; Paulich et al., 2018; A Vienne-Jumeau et al., 2019; Aliénor Vienne-Jumeau et al., 2020)

Since the promotion of an active life is closely related to the performance of functional activities performed with the best efficiency (Buoite Stella et al., 2020; Khan et al., 2007), hence, with low energy demand, training of this functional task is justified using a treadmill (Swinnen et al., 2012; Yeh et al., 2020). Recently, treadmill gait analysis has been proposed as an attractive alternative for overground walking measuring systems. The instrumented treadmill enables collection of gait performance over long periods of time and distance using standardized conditions (Riley et al., 2007)

Moreover, walking abnormalities in patients with MS are, nevertheless, poorly characterised (Coca-Tapia et al., 2021; Filli et al., 2018). In fact, there is a lack of normative values for pwMS regarding the performance of gait during walks of relatively long duration using different valid tools that allows us to infer about efficiency of gait (Socie et al., 2014).

Therefore, the main aim of this study was to explore whether the IMUs allow to identify suble changes in gait parameters in pwMS by trying to predict the relationship of the spatiotemporal variables with subjective measures of fatigue. We also assessed minimal spatiotemporal abnormalities in 6MWT correlation with reference values. In addition, we tried to infere about MS variability in a fatigued condition within this sample population.

To adress these goals it was performed a standardize protocol of gait, using IMUS while performing 6MWT in a treadmill, in a group of minimal walking impaired pwMS relapsing-remitting, according to HAI (range 0 - 1).

2. Methods

2.1. Study design

This is an observational case control study, being part of a large research project with pwMS, which include several variables.

2.2. Participants

Inclusion criteria included: i) aged between 18-64 years old, ii) neurologist confirmed diagnosis of definite relapsing-remitting MS according to the revised McDonald criteria, iii) relapse-free for at least 30 days prior to testing, iv) score between 0-1 on the HAI, v) ability to walk without an assistive device, and vi) cognitively ablility to understand and carry out the instructions (Filli et al., 2018; Kalron et al., 2013).

Exclusion criteria included: i) orthopedic disorders that could negatively affect mobility, ii) pregnancy, iii) blurred vision, iv) cardiovascular disorders or v) unavailability travel to the laboratory (Craig et al., 2017; Crenshaw et al., 2006; Eken et al., 2020; Kalron et al., 2013; Motl et al., 2012; B. M. Sandroff et al., 2014).

For more details about sample recruitment process see Figure 1.

In the present study, eleven individuals diagnosed with relapsing-remitting MS. Aged between 30-50 years (*M*= 40.09; *SD*= 6.41), who voluntarily answered a questionnaire disseminated via e-mail through members of the Sociedade Portuguesa de Esclerose Múltipla (SPEM), were selected for convenience.

All participants were characterized taking into account weight between 42-93kg (*M*=69.55; *SD*=19. 51), height between 153-190cm (*M*=166.55; *SD*=10.22), dominant limb, diagnosis between 36-300 months (*M*=147.09; *SD*= 86.46) and last relapse between 12-138 months (*M*=60.82; *SD*=41.62) in order to record their variability. All accomplished the inclusion criteria for HAI.

For more details about sample description see Table *1*.

The study conformed to the ethical norms of the Institutions involved and to the Declaration of Helsinki, dated 1964. Informed consent was obtained from all participants.

For more details about informed consents see Appendices 7.1.

Table 1
Participants Characteristics

Variables		*n*	%
Gender	Male	3	27.3
	Female	8	72.7
Dominant Limb	Right	10	90.9
	Left	1	9.1
HAI	0	4	6.4
	1	7	63.6
DMT	Avonex	1	9.1
	Ocrelizumab	1	9.1
	Fingolimod	2	18.2
	Tecfidera	4	36.4
	Refif 44	2	18.2

Note: *n*, sample size; HAI, Hausser Ambulation Index; DMT, disease-modified treatment

2.3. Instruments

2.3.1. Sample selection and characterization questionnaire

The selection and characterization of the sample was carried out through a questionnaire elaborated in the Google Forms tool (Appendix 7.2), where the sociodemographic information was gathered, and the participants' eligibility criteria were checked, as it is shown in the Figure 1.

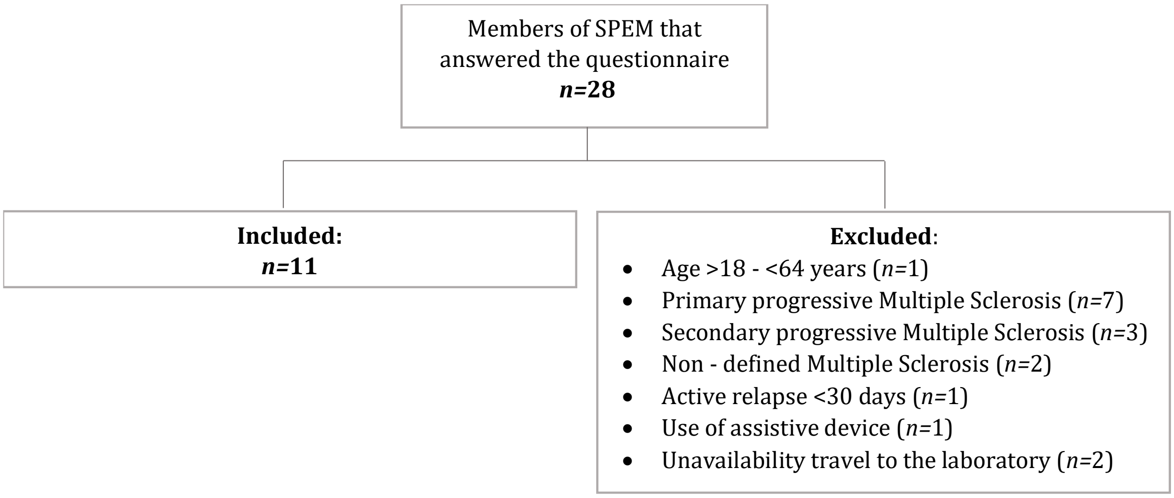


Figure 1
Sample Selection

2.3.2. Hausser Ambulation Index

HAI rates gait performance ranging from 0 (*no gait impairment*) to 9 (*restricted to wheelchair*) (Appendix 7.3). and it has been used in several studies focusing on patients suffering from MS (Hauser et al., 1983; Vaney et al., 1996; Wade, 1992), allowing to characterize and elect the study participants. This scale is validated for the Portuguese population and has excellent test-retest reliability (ICC= 0.94 - 1) (Resende, 2001; Santos et al., 2000; Syndulko et al., 1996).

2.3.3. Six minutes walk test

The 6MWT records the maximum distance a patient walks in six minutes and was performed in accordance with the instructions of the American Thoracic Society. For validation in pwMS, the original instructions were modified to emphasize speed selection and eliminate instructions for permitted rest, also the test was performed using a treadmill rather than the recommended 32 meters circuit (Bethoux & Bennett, 2011; Fry & Pfalzer, 2006; Goldman et al., 2008).

This is justified, since walking for six minutes can reflect the fatigue component common in pwMS and may prevent them from performing any significant physical activity or testing until they have rested (Bethoux & Bennett, 2011; Kalron et al., 2013).

The 6MWT test has high reliability (ICC= 0.95‑0.99) in pwMS (Bethoux & Bennett, 2011; Fry & Pfalzer, 2006) and is responsive to changes in deteriorating status in pwMS (Bethoux & Bennett, 2011; Paltamaa et al., 2008). A single repetition of the 6MWT was previously determined to be reliable in the MS population (Fry & Pfalzer, 2006).

2.3.4. Modified Borg Scale

Considering the importance of fatigability in pwMS, one way to measure walking impairment is through walking efficiency. It is hypothesised that with decreased energy expenditure for the same amount of walking it is improved walking efficiency. In order to measure the energy expenditure we used MBS as an indirect indicator for gait efficiency (Bethoux & Bennett, 2011).

The MBS is a 0 (*no exertion at all*) to 10 (*maximal*) rated numerical score used to determine the perceived workload when a patient is during submaximal exercise and is routinely administered during 6MWT, being a subjective measure of fatigue (G. Borg, 1998; G. A. Borg, 1982; Williams, 2017) (Appendix 7.4).

No reports on its validity and reliability were found for the population studied.

2.3.5. Inertial measurement units

The subjects were instrumented by 15 IMUs (Xsens MTw Awinda, Technology B.V., Enschede, The Netherlands) attached to the segments of the head, trunk, upper body, pelvis and lower body, through the use of a velcro, including: a IMU wirelessly (IMUw), Awinda Master interface between the PC running Xsens-based software (*KinetiKos*) and IMUw's and Awinda Station slots used for charging the IMUws and firmware updates (Paulich et al., 2018).

Each motion tracker sensor is featuring a tri-axial accelerometer (acceleration resolution 160 m/s), a tri-axial gyroscope (angular velocity rate resolution 2000 deg/s) and tri-axial magnetometer (magnetic field resolution 1,9 Gauss), unit weight 16 g, unit size 47 mm × 30 mm × 13 mm and sampling data rate at 1000 Hz. On board of the sensor, the Strap-Down Integration (SDI) algorithm is applied to the calibrated readings of the gyrosope and accelerometer. The output of the SDI, along with the calibrated magnetometer and barometer data, is then transmitted wirelessly using the Awinda Protocol to the Awinda Master available at user manual and online tutorials (https://tutorial. xsens.com/). The IMUw is powered using a LiPo battery, lasting for 6 hours. The IMUw is designed to be robust, easy and comfortable in usage, with easy placement on the body based on flexible hook and loop straps. (Paulich et al., 2018).

The Awinda Station is 148 mm × 104 mm × 31.9 mm in size. It includes the external antenna and six IMUw docking slots. Additionally, the Awinda Station has four Body Sensor Networks hardware connections for time-synchronization with third party devices (Paulich et al., 2018).

To minimize the efect of inter-individual diferences such as body weight, length, and general ability to walk, *KinetiKos* applies a routine for normalize the relative gait parameters changes.

2.3.6. Treadmill

For gait analysis, an electric Pulsar® 3p treadmill was used (h / p / cosmos® - Pulsar® 3p, Nußdorf, Germany). It also has an anti-fall system due to the use of a safety wire (h/p/cosmos sports & medical gmbh, 2015). This is an effective instrument for gait assessment in terms of speed (ICC = 1.00)(Hottenrott, K. , Schwesig, R., Hübel, 2005; Kalron et al., 2013; Kalron & Frid, 2015).

2.4. Procedures

The sample was recruited by the snowball effect, through an e-mail response according to the study objective.

Prior to the beginning of the recordings, a test of procedures was performed on an individual with similar characteristics to the sample, but who was not part of it. This aimed to verify the applicability and standardization of experimental procedures and instruments, as well as their duration in order to optimize the collection of data a posteriori.

Individuals who met the pre-established participation criteria and showed willingness to participate were contacted in order to schedule the data collection and were asked to bring with them shorts and a top, in the case of female individuals, and shoes that they wear usually (i.e. confortable and heel smaller than 5 cm).

Gait assessment was performed at the Center for Rehabilitation Research based at the School of Health of P.PORTO by two researchers simultaneously. The duration of the each participant´ data collection session was around 1 hour 45 minutes.

2.4.1. Sensors allocation

Prior to the beginning of the collection, each participant was equipped with the IMUs by the researchers.

The head´ IMU was attached laterally in the middle of skull above the ear turned backwards, front trunk´ IMU was attached above the manubrium turned upwards and back trunk´ IMU was attached to the segment roughly at half the distance between the left and right spinae illiacae posteriores superiores turned downwards. Each arm' IMU was attached laterally in the middle of humerus, wrist' IMU was attached laterally just between distal radio-ulnar joint turned upwards so do hand' IMU attached in the dorsal of metacarpal bones turned upwards. Each thigh´ IMU was attached to the segment approximately at proximal one-third the distance between the greater trochanter and the lateral epicondyle turned backwards. Each shank´ IMU was attached roughly at proximal one-third the distance between the lateral epicondyle and the lateral malleolus turned backwards. Each foot´ IMU was attached roughly at three-fourth the distance between the calcaneus and the head of the second metartarsal turned upwards (Teufl et al., 2019).

Prior to start the testing, all the sensors were turned on, synchronized and calibrated with the *KinetiKos* software. Once everything was set-up it was selected the treadmill speed.

2.4.2. Treadmill speed setting

In order to establish each individual speed, each participant was instructed to walk along ten meters in a walkway, being informed to use a self-selected walking speed (SSWS) that best characterize his/her (Kalron & Frid, 2015; Sehle et al., 2011).

It was collected three times the one way 10 meters distance. The collected data were entered into the *KinetiKos* online platform using the "*Gait*" module for data analysis. From each report the *KinetiKos* collected the "*mean velocity*" in meters per second. It was calculated the mean of the three *mean velocity* in an excel sheet, being converted from meters per second (i.e. the units exported from the platform) to kilometer per hour (i.e. treadmill speed).

The treadmill speed was set between 2.30 – 4.40 km/h (*M*= 3.69, *SD*= 0.63).

When the treadmill speed was obtained, all participants actively participated in an adaptation-familiarization trial in order to responded whether it would be comfortable to keep the speed at least for 6 minutes. The eyes were directed to a visual reference placed at eye level on the wall a few centimeters away. Starting at a fixe speed of 0.5 km/h, the belt speed was increased by 0.3 km/h every 15 seconds in a stepwise manner, until his/her comfort speed is obtained, the speed kept for a few minutes and then the speed was decreased in the reverse way (Figure 2) (Kalron et al., 2013; Kalron & Frid, 2015; Sehle et al., 2011). This trial took around 10 minutes in total, followed by 5 minutes rest.

2.4.3. Treadmill recording

Following this adaptation phase, each participant was instructed to walk on treadmill following the previous protocol described, explained also in Figure 2 (Kalron et al., 2013; Kalron & Frid, 2015).

Along each trial, it was recorded the MBS value at the beginning and at the end of 6MWT period.

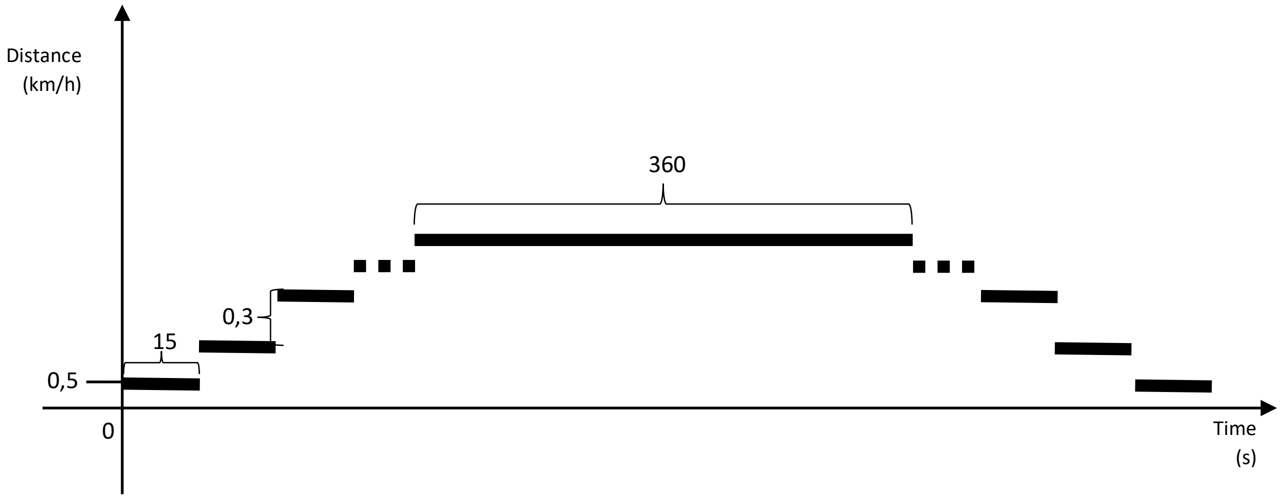


Figure 2
Protocol for Sample Recording

It was recorded six repetitions of each full trial. To avoid fatigability, participants were instructed to have 5 minutes rest between each trial.

2.4.4. Data analysis

Data relating to the identification of participants in this study are confidential, coded and entered into a computer system, where only the researcher has access with a password, and this principle is always maintained throughout the entire investigation.

The comprehensive set of 19 spatiotemporal parameters examined here included as indicators of basic walking function of lower limb movements (Weller et al., 2020), plus, values of MBS as reference for subjective measure of fatigue.

It was computed the mean of the six assesment moments to create a norm of each participant (Filli et al., 2018; Weller et al., 2020).

The increment and decrement of speed were removed from the sample analysis, only the 6MWT was considered.

2.4.5. Statistics

Statistical Analysis was performed using IBM SPSS Statistics® software v27.

Descriptive statistics and frequency analyses were conducted.

Reliability test were conducted on the 19 spatiotemporal variables. Cronbach's Alpha is considered for internal consistency with: $0.9 \leq \alpha$ (*excellent*), $0.8 \leq \alpha < 0.9$ (*good*), $0.7 \leq \alpha < 0.8$ (*acceptable*), $0.6 \leq \alpha < 0.7$ (*questionable*), $0.5 \leq \alpha < 0.6$ (*poor*), $\alpha < 0.5$ (*unacceptable*) (Cortina, 1993).

To verify the variables distribution it was performed the Shapiro-Wilk test. The choice of using the non-parametric tests was due to the limited sample size.

Spearman’s rank correlation coefficient was used to examine the relationship between spatiotemporal variables and subjective measures of fatigue, due to non-normal distribution of the investigated variables.

In order do compare the spatiotemporal variables abnormalities during 6MWT with reference values it was used one sample T-test for normal distribution metrics and Wilcoxon signed rank test for non-normal distribution metrics.

All reported *P* values were two-tailed. The level of significance was set at $P < .05$ (Marôco, 2018).

3. Results

The sample distribution for each variable is summarized in Appendix 7.5.

3.1. Study variables reliability

For the present sample ($n = 11$), the results revealed that the reliability of the measures between assessment moments range from questionable ($\alpha < 0.6$) to excellent ($\alpha > 0.9$). For the variables of subjective measure of fatigue, cadence and stride time the data is loaded rather excellent ($\alpha > 0.9$), for the variables step time of left leg the data is loaded rather good ($0.8 > \alpha < 0.9$). In the same way, for the variables speed, gait deviation index of left leg, and step time of right leg the data is loaded rather acceptable ($0.7 > \alpha < 0.8$), for the variables gaid deviation index, swing time of left leg, double support fraction of right leg and stance time of left leg the data is loaded questionable ($0.6 > \alpha < 0.7$). In addiction, for the variables speed, gait deviation index of left leg, and step time of right leg the data is loaded rather poor ($0.5 > \alpha < 0.6$), for the variables gait deviation index of right leg and step width the data is loaded questionable ($0.6 > \alpha < 0.7$), and for the variables of assimetry of step time and step length, swing time of left leg, double support fraction of left leg, stance time of right leg, stance time of right leg, step length of both legs the data is loaded unacceptable ($\alpha < 0.5$).

Table *2* presents the variance coefficients and the Cronbach's Alpha for each variable.

For more details about co-variance test see Appendix 7.6.

Table 2

Reliability Analysis of Study variables

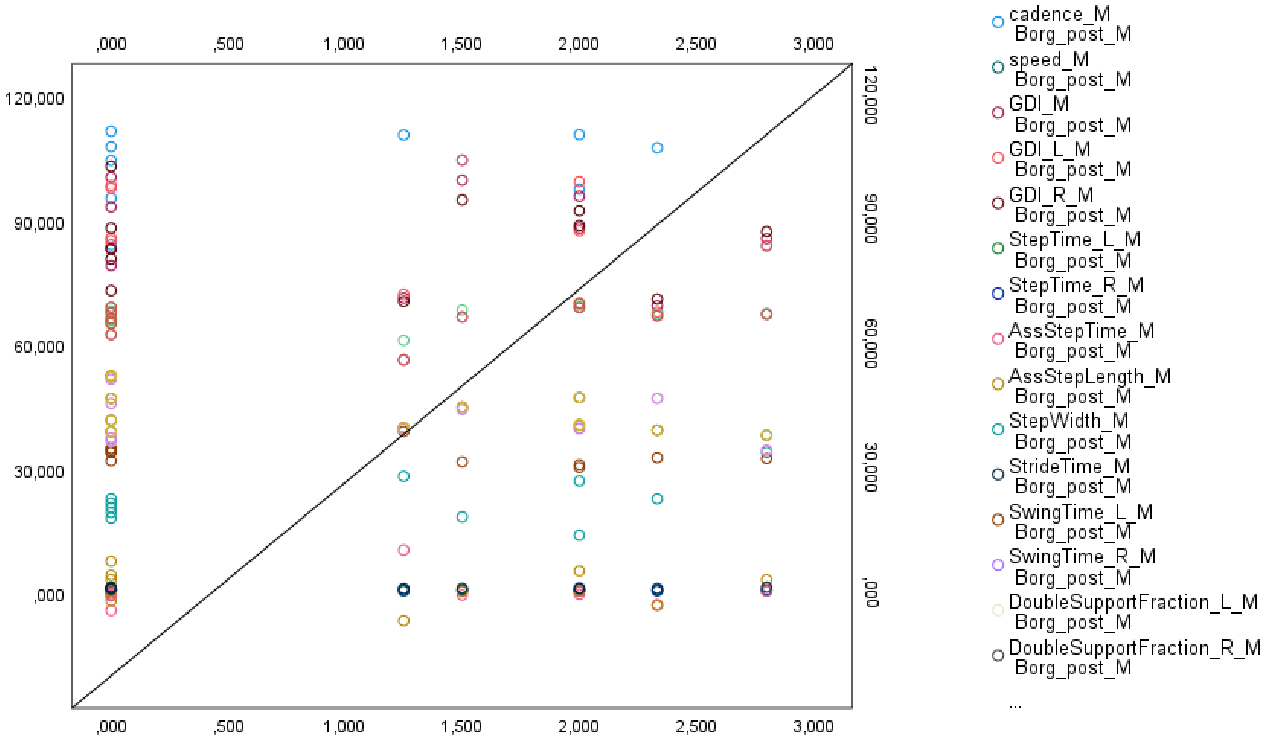
Variables	**Variance coefficient**	α	***N* of itens**
Cadence (steps per minute)	2964.17	0.997	6
Speed (meters per second)	0.62	0.743	
GDI (%)	4915.86	0.669	
GDI_L (%)	5811.63	0.723	
GDI_R (%)	4752.79	0.556	
StepTime_L (seconds)	0.22	0.832	
StepTime_R (seconds)	0.14	0.734	
AssStepTime (%)	602.76	0.141	
AssStepLength (%)	712.15	0.163	
StepWidth (centimeters)	724.65	0.552	
StrideTime (seconds)	0.48	0.998	
SwingTime_L (%)	258.35	0.604	
SwingTime_R (%)	591.54	0.494	
DoubleSupportFraction_L (%)	228.91	-0,231	
DoubleSupportFraction_R (%)	158.73	0.661	
StanceTime_L (%)	258.35	0.604	
StanceTime_R (%)	591.54	0.494	
StepLength_L (centimeters)	837.89	0.308	
StepLength_R (centimeters)	1032.92	0.207	
Borg (units)	36.03	0.977	

Note: α. Cronbach's Alpha

3.2. Correlation between spatiotemporal variables and subjective measures of fatigue

Spearman' s rank correlation coefficient were run to assess the relationships between spatiotemporal variables and subjective measures of fatigue.

No correlation was found as shown in Figure 3.



Note: *Black Line*, linear regression lines

Figure 3
Correlation Between Spatiotemporal Variables and Subjective Measures of Fatigue

For more details about Spearma's rank correlation test see Appendix 7.7.

3.3. Spatiotemporal variables abnormalities during six minutes walking

A one sample t-test was performed to compare variables with normal distribution metrics against the reference values.

There was not a significant difference in the scores for assimetry of step length (*M*= 1.23, *SD*= 4.10) variable, *t*(10) = 0.99, *P* = 0.342.

There was a significant difference in the scores of gait deviation performance index (*M*=86.25; *SD*= 10.51), gait deviation index of left leg (*M*= 87.76; *SD*= 11.46) and of right leg (*M*= 84.75; *SD*= 10.39) according to the reference value *t*(10)= -4.34, *P*= .001, t(10)= -3.54, *P*= .005 and *t*(10)= -4.87, *P*= .001, respectively. In the same way, it is reported a significant diference in the scores of swing time of left leg (*M*= 33.34; *SD*= 2.42), double support fraction of left leg (*M*=41.39; *SD*= 5.13) and right leg (*M*= 43.84: *SD*=5.24) considering the reference value *t*(10)= 17.06, *P*= < .001 and *t*(10)= 18.27, *P*= < .001, respectively. It is also shown a significant difference in the score for stance time for left leg (*M*= 66.66; *SD*= 2.42), *t*(10)= 9.14. *P*= < .001 (Table 3).

These results suggest that the assimetry of step length is very similar to healthy people. The other variables differ significantly from the reference values.

Table *3*

One Sample T- Test for Normal distribution Spatiotemporal Variables According to the Reference Value

Variables	***Test value***	***M***	***SD***	***df***	***t***	***P***	***Cohen's D***
GDI_M (%)	100	86.25	10.51	10	-4.34	.001	-1.31
GDI_L_M (%)	100	87.76	11.46	10	-3.54	.005	-1.07
GDI_R_M (%)	100	84.75	10.39	10	-4.87	.001	-1.47
AssStepLength_M (%)	0	1.23	4.10	10	0.99	.342	0.3
SwingTime_L_M (%)	40	33.34	2.42	10	-9.14	< .001	-2.75
DoubleSupportFraction_L_M (%)	15	41.39	5.13	10	17.06	< .001	5.14
DoubleSupportFraction_R_M (%)	15	43.84	5.24	10	18.27	< .001	5.51
StanceTime_L_M (%)	60	66.66	2.42	10	9.14	< .001	2.75

Note: *Test value,* percentual refence value; *M*, mean; *SD*, standard deviation; *df*, degrees of freedom; *t*, test statistic; *P*, significance level

A Wilcoxon signed rank test was performed to compare variables with non-normal distribution metrics against the reference values for the same variables.

There were no significant difference in the score for assimetry of step time (*Md*= 0, *n*=11) according to reference value *Z*=18, *p*= .182.

The Wilcoxon signed rank test indicates that there was a significant difference for swinf time (*Md*=40, *n*=11) and stance time of right leg (*Md*=60, *n*=11), *Z*=66, *P*= .003 and *Z*=64, *P*= .006, respectively (Table 4).

These results suggest that the assimetry of steps is very similar to healthy people. The other variables differ significantly from the reference values.

Table *4*

Wilcoxon Signed Rank Test for Non- Normal distribution Spatiotemporal Variables According to the Reference Value

Variables	***Test value***	***SD***	***Z***	***P***
AssStepTime_M (%)	0	11.25	18	.182
SwingTime_R_M (%)	40	11.23	66	.003
StanceTime_R_M (%)	60	11.25	64	.006

Note: *Test value,* percentual refence value; *SD*, standard deviation; *Z*, test statistic; *P,* significance level

4. Discussion

The aim of the present investigation was to explore whether the IMUs allow to identify suble changes in a group of minimal walking impaired pwMS relapsing-remitting, through the prediction of the relationship of the spatiotemporal variables with subjective measures of fatigue. In fact, the use of instrumental methods, like treadmill and IMUs, allows us to obtain quantitative variables, increasing the sensitivity of clinical and performance tests and identifying the evolution in gait in MS (Angelini et al., 2019; A Vienne-Jumeau et al., 2019).

In research, there are several studies related to gait characterization in pwMS, using different tests, scales, heterogeneous sample and different inclusion criteria, collecting protocols, being this in line with the disease variability. For this study, we used a standardize protocol, using daily clinical scales and tests, trying to addressing the investigation goals with objective tools and data collection, in a homogeneous sample of minimal walking impaird pwMS relapsing-remitting.

As a matter of fact, current clinical performance tests (i.e.HAI or 6MWT) allow for identifying impaiments in gait in pwMS, associating different components, both clinical symptoms and functional capacities (B. Sandroff et al., 2015; A Vienne-Jumeau et al., 2019). However, they provide a general view of the impact of the disease on the patien's various functions, they cannot be as sensitive to detect gait alteration as specific index of gait.

The use of treadmill has several advantages once it requires less space and it allow us to measure walking over relatively long distances, possibly reflecting the fatigue component common in pwMS (Kalron et al., 2013). Also, one inclusion criteria, confirmed using HAI, was being able to walk without any assistive device, hence, no need to use handrails during treadmill walking, once it has a profound effect on gait patterns and obscures walking impairment (Filli et al., 2018). This fact represents a limitation of the present study is that only patients able to walk without assistance may not be represent the full spectrum of MS-related gait disorders (Filli et al., 2018).

The variables of this study were obtained during treadmill walking, with the velocity customized according to the individual walking capacity, and this might not completely reflect spontaneous, everyday, overground walking, as it is reported in other studies as "the treadmill sets the terms" (Filli et al., 2018; Weller et al., 2020). However, assessing gait while allowing patients to walk at their preferred speed is widespread due to its relevance to everyday life (Filli et al., 2018). Regardless, there is literature that supports the conclusion that the basic biomechanics of treadmill walking are highly similar to overground walking given sufficient acclimatisation to treadmill walking prior to gait analysis (Filli et al., 2018). In fact, this adaptation period was taken into account, as much as resting periods between trials.

To be sure, according to guidelines proposed by the MS Council for Clinical Practice Guidelines, fatigue is defined as a "subjective lack of physical and/or mental energy that is perceived by the individual or caregivers to interfere with usual and desired activities" (Sehle et al., 2011). Within this definition, the term "*subjective"* implies that fatigue is not measurable, may be psychogenic or not even exist. Once the decrease of energy expenditure it is related with growing in gait efficiency, we hypothesized that values of MBS (i.e. as a subjective measure of fatigue) could be used as a reliable measure for gait efficiency, that was not confirmed in our study. No correlation was found between self-reported fatigue and spatiotemporal variables.

As suggestion for the future it would be interesting to use instrumented material to directly measure gait efficiency (e.g., electromyographic signal, oxygen consumption), as long as take into account other factors afecting efficiency such as sleeping disorder (Theunissen et al., 2021).

It was also explored the minimal spatiotemporal abnormalities in 6MWT correlation with reference values of *KinetiKos* by their IMUs system together with treadmill.

For this purpose, it was used percentual reference values provenient from healthy persons. However, as previous studies have shown, gait spatiotemporal variables of pwMS differ from those of healthy persons (Cameron et al., 2008; Huisinga et al., 2014). This matches with our results for differences tests performed, given that, the only value that does not reported significant difference to refence value was assimetry of step length and time. Since all the other variables differ statistically from the healthy persons, this is a great indicator for IMUs being a reliable tool for measure minimal changes not visible to naked eye.

Besides the study of Coca-Tapia et al. suggesting that the gait pattern alteration do not appear in the earliest phase of the disease, there is a stronger consensus related to the worsen the pronouncing of changes with increseases of impairment (Craig et al., 2017; Filli et al., 2018; Huisinga et al., 2013; Kalron et al., 2013; Kelleher et al., 2010; Sehle et al., 2011; Weller et al., 2020).

When we are facing a neural impairment, this can lead to the observation of compensatory strategies in pwMS, in order to reduce the risk of falling and increase stability (Buoite Stella et al., 2020; Chung et al., 2016; Craig et al., 2017; Eken et al., 2020; Remelius et al., 2008). Studies in different animal species and humans indicated that a set of interneurons, the central pattern generator (CPG) network, located in the lumbar spinal cord generates the basic alternating pattern of leg muscles for walking, important for motor control during walking (Filli et al., 2018; Kalron et al., 2013; Weller et al., 2020). The CPG is modulated by descending supraspinal and peripheral afferent input and is involved in the speed-dependent modulation of gait in animals and humans, requiring a particular high degree of neural organization and collaboration between CNS motor centres. Interaction between supraspinal (e.g., cortex and brainstem) and spinal (e.g., CPG) networks can be affected by autoimmune-mediated inflammatory processes, for instance, involving long, well-myelinated, descending and ascending fibre tracts which represent predilection sites for lesions in MS, better than the affection of CPG (Filli et al., 2018; Weller et al., 2020). In addition, patients with a begining course of MS have shown increased cerebral activity which may represent some form of compensation, as much as an increased central activation during fatiguing exercises probably reflecting an additional compensatory central activation.

Thus, observed deterioration of gait parameters in exhausted patients could also reflect a breakdown of these compensatory mechanisms (Sehle et al., 2011). Unfortunately, magnetic resonance imaging (MRI) of the brain and spinal cord of reasonable and comparable quality were not available for the majority of the examined subjects in this study and, therefore, could not be correlated with our functional findings.

We speculate that pwMS may have favored an asymmetrical position for reasons of safety and motor control, for example, left leg presents bigger impairment for this sample (i.e. considering that positve values means of right leg performance for these variables is bigger than left leg)(Craig et al., 2017; Kalron & Frid, 2015; Sehle et al., 2011).

As well, we pretended to inference of about MS variability in a fatigued condition.

In line with our discussion measuring variability during gait in pwMS can provide information about the sensorimotor control (Craig et al., 2017), being this increased for this population. *Variability* in a biological sense as “the power possessed by living organisms, of adapting themselves to modifications or changes in their environment, thus possibly giving rise to ultimate variation of structure or function”. *Statistical variability* refers to measures of centrality around a mean or an average and includes measures such the standard deviation, the range of possible values, and the variance. All of these definitions contribute to understanding of human variability. *Human movement variability* encompasses the normal variations that occur in motor performance across multiple repetitions of a task over time, being useful to understanding the predictability of movement. Variability is inherent within all biological systems and reflects variation in both space and time, which can be illustrated easily in human movement. Variability is inherent in biological systems because it ensures survival (Harbourne & Stergiou, 2009).

It is important to state that currently there is no gold standard to quantify gait variability. It is known that pwMS have decreased step length and cadence and increased step width and double support phase, decreased SSWS, muscle weakness, altered muscle activation patterns leading to muscle fatigue (Filli et al., 2018; Kalron, 2016; Kalron et al., 2013; Moon et al., 2017; Socie et al., 2013)

In fact, in our study we performed covariance analysis, as this might be a better Test due using full sample results, for the study variables and only fatigue, cadence and stride time variables showed excellent measures. The other variables revealed different reliability. The results expressed no consistency for this sample group.This might be due to the small sample size that may have impacted the power to detect internal consistency in the variables studied. The small sample size, resulting from the attempt of maximising the cohort match and due to Covid-19 pandemic situation during sampling collection.

This study has some more limitations that should be addressed in the future, like the implication of disease-modified treatment. Furthermore, future research should be focused on general disease severity without evaluating how it would depend on the participan’s functional status regarding known impairments such as spasticity, cerebellar status, sensitivity deficit or motor deficiency. IMUs should also be used in individual longitudinal follow-up, as long as the full information provided by full body sensors placed and angular data.

5. Conclusion

In conclusion, IMUs is a effective instrumentto identify suble changes linked to spatiotemporal variables for this sample group.

We found no correlation between self-reported fatigue and spatiotemporal variables. , as this is not a valid tool to measure subjectively gait efficiency.

It is also possible to state that the measure of variability used in this study was not sensitive enough.

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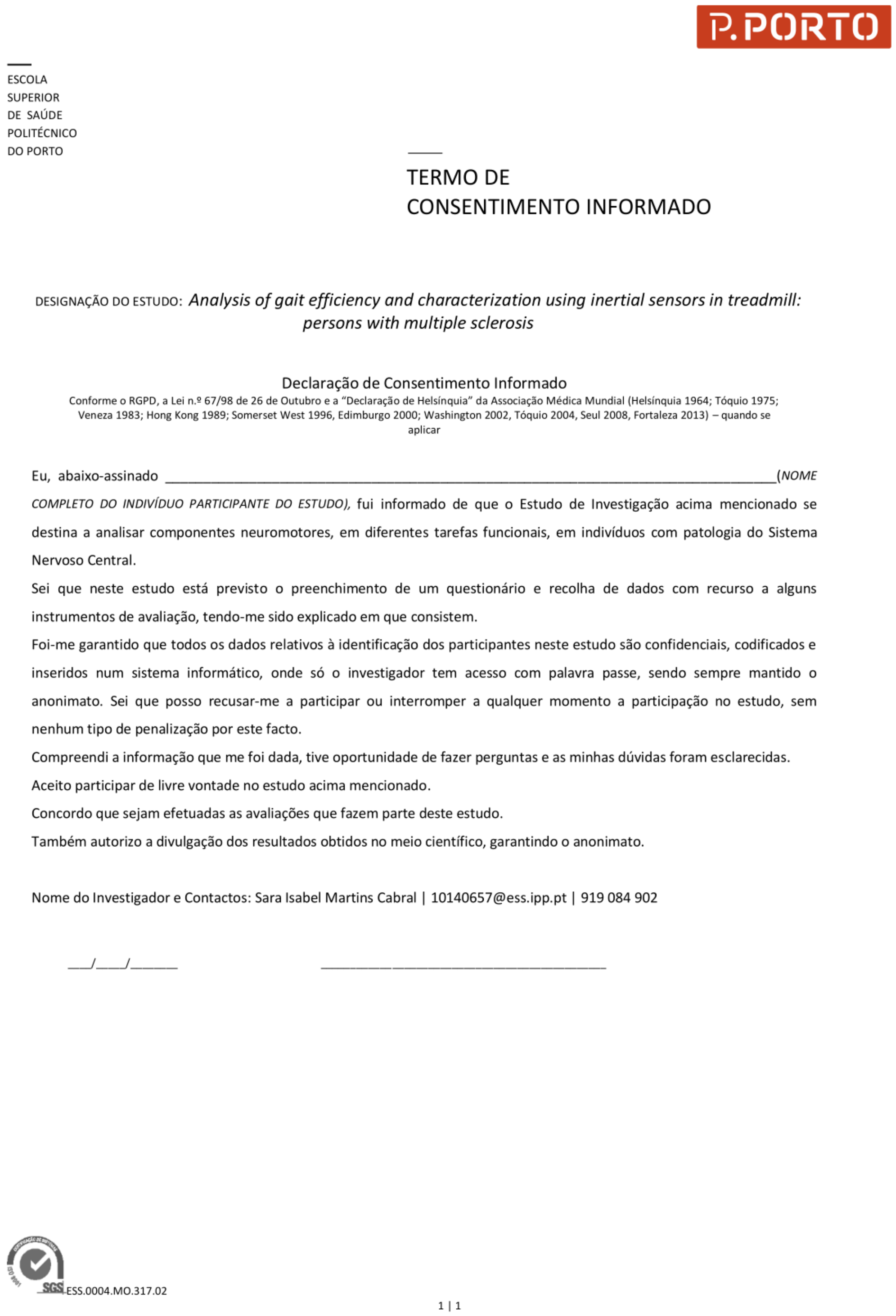
7. Appendices

7.1. Informed Consent for participants



P.PORTO

ESCOLA
SUPERIOR
DE SAÚDE
POLITÉCNICO
DO PORTO

TERMO DE
CONSENTIMENTO INFORMADO

DESIGNAÇÃO DO ESTUDO: *Analysis of gait efficiency and characterization using inertial sensors in treadmill: persons with multiple sclerosis*

Declaração de Consentimento Informado

Conforme o RGPD, a Lei n.º 67/98 de 26 de Outubro e a "Declaração de Helsínquia" da Associação Médica Mundial (Helsínquia 1964; Tóquio 1975; Veneza 1983; Hong Kong 1989; Somerset West 1996, Edimburgo 2000; Washington 2002, Tóquio 2004, Seul 2008, Fortaleza 2013) – quando se aplicar

Eu, abaixo-assinado ____(*NOME COMPLETO DO INDIVÍDUO PARTICIPANTE DO ESTUDO),* fui informado de que o Estudo de Investigação acima mencionado se destina a analisar componentes neuromotores, em diferentes tarefas funcionais, em indivíduos com patologia do Sistema Nervoso Central.

Sei que neste estudo está previsto o preenchimento de um questionário e recolha de dados com recurso a alguns instrumentos de avaliação, tendo-me sido explicado em que consistem.

Foi-me garantido que todos os dados relativos à identificação dos participantes neste estudo são confidenciais, codificados e inseridos num sistema informático, onde só o investigador tem acesso com palavra passe, sendo sempre mantido o anonimato. Sei que posso recusar-me a participar ou interromper a qualquer momento a participação no estudo, sem nenhum tipo de penalização por este facto.

Compreendi a informação que me foi dada, tive oportunidade de fazer perguntas e as minhas dúvidas foram esclarecidas.

Aceito participar de livre vontade no estudo acima mencionado.

Concordo que sejam efetuadas as avaliações que fazem parte deste estudo.

Também autorizo a divulgação dos resultados obtidos no meio científico, garantindo o anonimato.

Nome do Investigador e Contactos: Sara Isabel Martins Cabral | 10140657@ess.ipp.pt | 919 084 902

___/____/______ ______________________________________

ESS.0004.MO.317.02

1 | 1

7.2. Sample collection and characterization questionnaire

"No âmbito do Projeto de Investigação "*Analysis of gait efficiency and characterization using inertial sensors in treadmill: people with multiple sclerosis* " da Escola Superior de Saúde Instituto Politécnico do Porto sob a orientação da Professora Doutora Augusta Silva, convidámo-lo a participar num questionário que pretende selecionar uma amostra para a realização do estudo científico.

O questionário é anónimo e serão necessários cerca de três minutos para responder a todas as perguntas.

Gratos pela colaboração.

1. Iniciais do seu nome (primeiro e último):

____

2. Sexo:

☐ Masculino

☐ Feminino

3. Idade (anos):

____

4. Contacto telefónico[1]:

____

5. E-mail[1]:

____

6. Peso (kg):

____

7. Altura (cm):

____

8. Atividade profissional (prévia ou atual):

____

9. Membro inferior dominante (se tivesse de dar um pontapé numa bola, qual escolheria?):

☐ Direito

☐ Esquerdo

10. É portador de Esclerose Múltipla?

☐ Sim

---

[1] estes dados são necessários para contato dos participantes no caso de reunirem os critérios de seleção da amostra

☐ Não

11. Qual o tipo de Esclerose Múltipla?
☐ Pediátrica
☐ Surto- Remissiva
☐ Primária Progressiva
☐ Secundária Progressiva
☐ Indefinida

12. Há quanto tempo foi diagnosticado (meses)?
____

13. Quando sofreu o último surto (mm/aaaa)?
____/_________

14. Toma alguma medicação?
☐ Sim
☐ Não
14.1. Qual?____

15. Utiliza algum auxiliar de marcha nas suas deslocações (Entenda-se por "auxiliares de marcha" todos produtos desenvolvidos para dar apoio na marcha e equilíbrio, como bengalas, canadianas, andarilhos, tripés, cadeira de rodas ou outro)?
☐ Sim
☐ Não

16. Já foi sujeito a alguma intervenção cirúrgica?
☐ Sim
☐ Não
16.1. Qual?____
16.2. Há quanto tempo?
☐ Menos de 3 meses
☐ 3 a 6 meses
☐ 6 a 12 meses
☐ Mais de 12 meses

17. Tem alguma dor mantida há pelo menos 3 meses?

☐ Sim

o Não

17.1. Onde?____

18. Está disponível para ser contactado (a) para a participar neste estudo?

☐ Sim

☐ Não

Obrigada pela colaboração, qualquer dúvida poderá entrar em contacto através do email: smaugusta@gmail.com”

7.3. Hauser Ambulation Index

☐ 0 = Asymptomatic; fully active.

☐ 1 = Walks normally, but reports fatigue that interferes with athletic or otherdemanding activities.

☐ 2 = Abnormal gait or episodic imbalance; gait disorder is noticed by family andfriends; able to walk 25 feet (8 meters) in 10 seconds or less.

☐ 3 = Walks independently; able to walk 25 feet in 20 seconds or less.

☐ 4 = Requires unilateral support (cane or single crutch) to walk; walks 25 feet in 20seconds or less.

☐ 5 = Requires bilateral support (canes, crutches, or walker) and walks 25 feet in 20 seconds or less; *or* requires unilateral support but needs more than 20 seconds to walk 25 feet.

☐ 6 = Requires bilateral support and more than 20 seconds to walk 25 feet; may use wheelchair* on occasion.

☐ 7 = Walking limited to several steps with bilateral support; unable to walk 25 feet;may use wheelchair* for most activities.

☐ 8 = Restricted to wheelchair; able to transfer self independently.

☐ 9 = Restricted to wheelchair; unable to transfer self independently.

7.4. Modified Borg Scale

Score	Level of exertion
0	No exertion at all
0.5	Very, very slight (just noticeable)
1	Very slight
2	Slight
3	Moderate
4	Somewhat severe
5	Severe
6	
7	Very severe
8	
9	Very, very severe (almost maximal)
10	Maximal

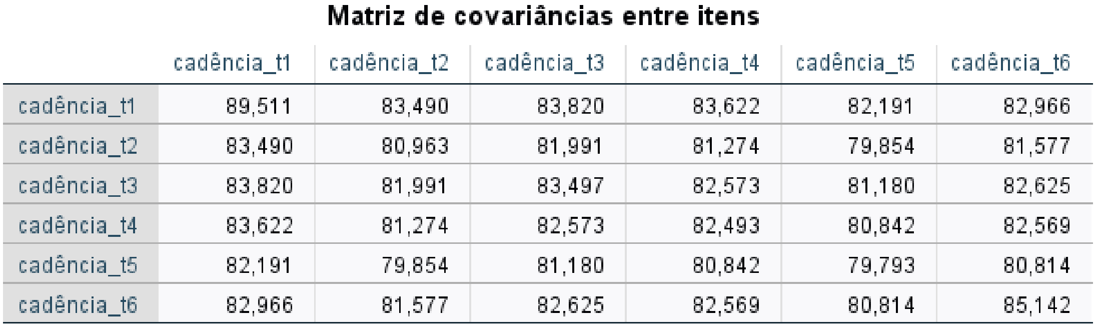
7.5. Variables distribution

Table *5*
Shapiro Wilk Descriptive Statistics

Variables	*P*	*M*	*Md*	*σ2*	*SD*	*Range*	*Skewness*	*κ*
Cadence (steps per minute)	.034	101.59	104.5	102.88	10.149	83.79 - 111.46	-0.98	-0.33
Speed (meters per second)	.671	0.75	0.77	0.20	0.14	0.52 - 0.98	0.15	-0.19
GDI (%)	.616	86.25	85.41	110.38	10.51	69.38 - 100.37	-0.23	-0.89
GDI_L (%)	.485	87.76	85.77	131.45	11.46	67.78 - 104.43	-0.30	-0.58
GDI_R (%)	.669	84.75	87.25	107.96	107.96	70.39 - 102.99	0.04	-0.66
StepTime_L (seconds)	.728	0.60	0.58	0.01	0.08	0.44 - 0.72	-0.08	0.49
StepTime_R (seconds)	.051	0.60	0.57	0.01	0.07	0.53 - 0.72	0.79	-0.81
AssStepTime (%)	< .01	0.12	-0.50	13.48	3.67	- 4.23 - 10.35	2.37	7.32
AssStepLength (%)	.950	1.23	0.66	16.8	4.10	-6.68 - 7.66	-0.41	0.04
StepWidth (centimeters)	.709	22.44	21.68	30.72	5.54	13.95 - 33.96	0.73	0.70
StrideTime (seconds)	.130	1.19	1.15	0.02	0.13	1.08 - 1.43	1.18	0.13
SwingTime_L (%)	.239	33.34	32.67	5.85	2.42	30.30 - 39. 01	1.21	2.14
SwingTime_R (%)	.016	66.02	66.88	14.67	3.83	56.28 - 69.98	-1.86	4.01
DoubleSupportFraction_L (%)	.461	41.39	39.73	26.33	5.13	34.45 - 51.85	0.73	-0.11
DoubleSupportFraction_R (%)	.102	43.84	41.71	27.41	5.24	38.08 - 52.45	0.67	-0.99
StanceTime_L (%)	.239	66.66	67.33	5.85	2.41	60.99 - 69.70	-1.21	2.14
StanceTime_R (%)	.016	66.02	66.88	14.67	3.83	656.28 - 69.98	-1.86	4.01
StepLength_L (centimeters)	.461	41.39	39.74	26.33	5.13	34.45 - 51.58	0.73	-0.11
StepLength_R (centimeters)	.102	43.84	41.71	27.41	5.24	38.08 - 52.45	0.67	-0.99
Borg (units)	.022	1.08	1.25	1.23	1.11	0 - 2.80	0.22	-1.79

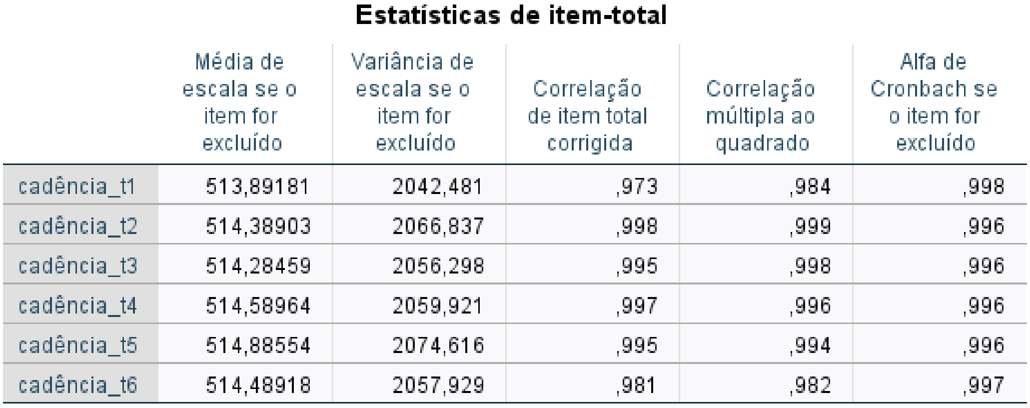
Note: *P*, significance level; *M,* mean*; Md,* median; *σ2,* variance level; *κ,* kurtosis

7.6. Co-variance statistics detailed results



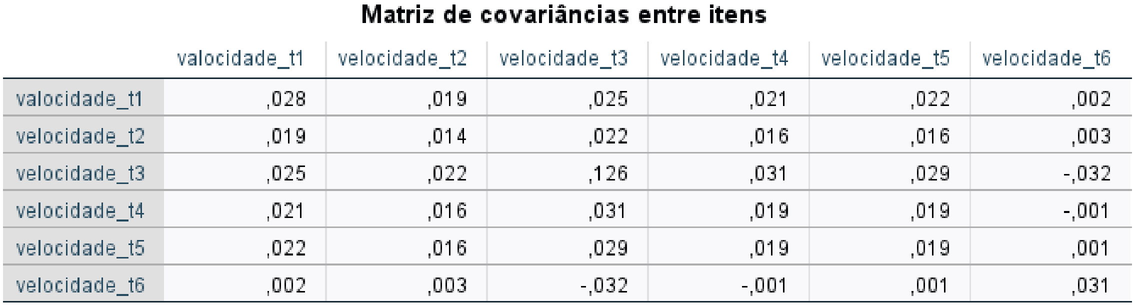
Matriz de covariâncias entre itens

	cadência_t1	cadência_t2	cadência_t3	cadência_t4	cadência_t5	cadência_t6
cadência_t1	89,511	83,490	83,820	83,622	82,191	82,966
cadência_t2	83,490	80,963	81,991	81,274	79,854	81,577
cadência_t3	83,820	81,991	83,497	82,573	81,180	82,625
cadência_t4	83,622	81,274	82,573	82,493	80,842	82,569
cadência_t5	82,191	79,854	81,180	80,842	79,793	80,814
cadência_t6	82,966	81,577	82,625	82,569	80,814	85,142



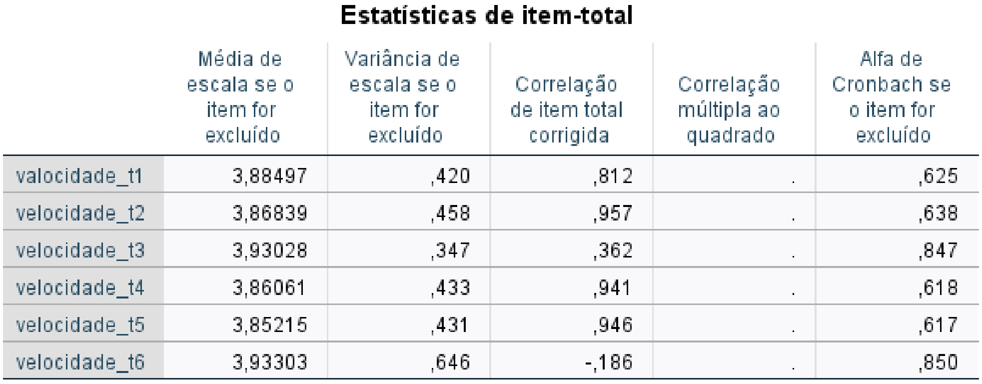
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
cadência_t1	513,89181	2042,481	,973	,984	,998
cadência_t2	514,38903	2066,837	,998	,999	,996
cadência_t3	514,28459	2056,298	,995	,998	,996
cadência_t4	514,58964	2059,921	,997	,996	,996
cadência_t5	514,88554	2074,616	,995	,994	,996
cadência_t6	514,48918	2057,929	,981	,982	,997



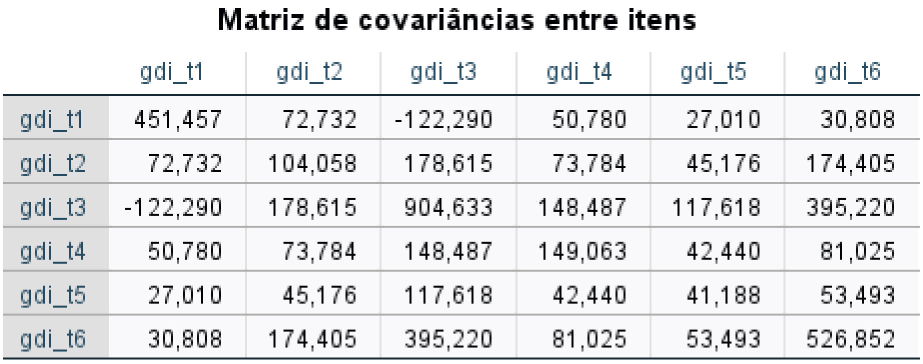
Matriz de covariâncias entre itens

	valocidade_t1	velocidade_t2	velocidade_t3	velocidade_t4	velocidade_t5	velocidade_t6
valocidade_t1	,028	,019	,025	,021	,022	,002
velocidade_t2	,019	,014	,022	,016	,016	,003
velocidade_t3	,025	,022	,126	,031	,029	-,032
velocidade_t4	,021	,016	,031	,019	,019	-,001
velocidade_t5	,022	,016	,029	,019	,019	,001
velocidade_t6	,002	,003	-,032	-,001	,001	,031



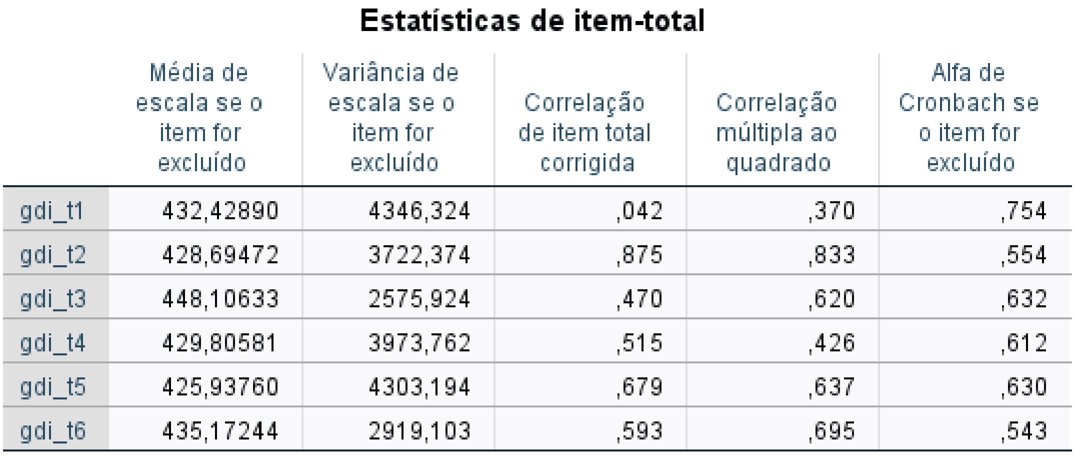
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
valocidade_t1	3,88497	,420	,812	.	,625
velocidade_t2	3,86839	,458	,957	.	,638
velocidade_t3	3,93028	,347	,362	.	,847
velocidade_t4	3,86061	,433	,941	.	,618
velocidade_t5	3,85215	,431	,946	.	,617
velocidade_t6	3,93303	,646	-,186	.	,850



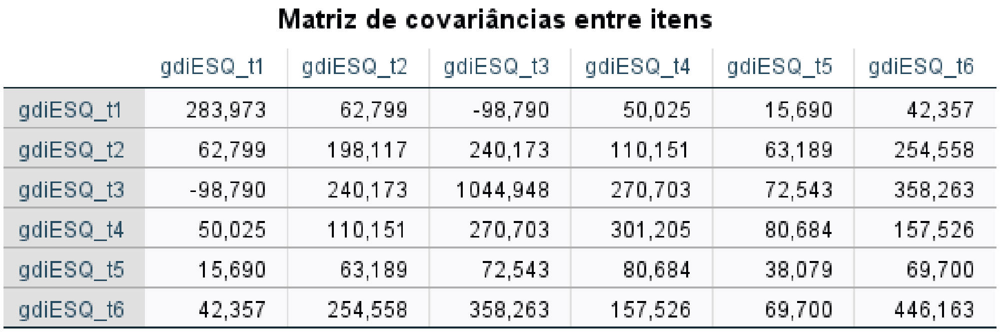
Matriz de covariâncias entre itens

	gdi_t1	gdi_t2	gdi_t3	gdi_t4	gdi_t5	gdi_t6
gdi_t1	451,457	72,732	-122,290	50,780	27,010	30,808
gdi_t2	72,732	104,058	178,615	73,784	45,176	174,405
gdi_t3	-122,290	178,615	904,633	148,487	117,618	395,220
gdi_t4	50,780	73,784	148,487	149,063	42,440	81,025
gdi_t5	27,010	45,176	117,618	42,440	41,188	53,493
gdi_t6	30,808	174,405	395,220	81,025	53,493	526,852



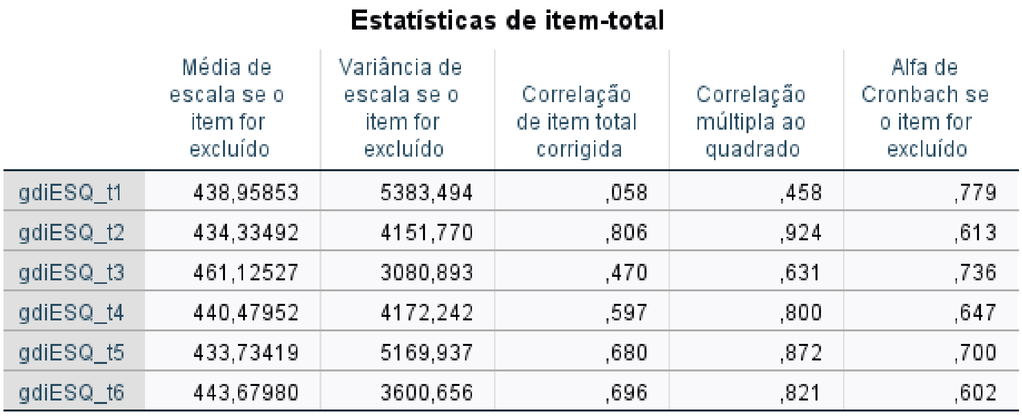
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
gdi_t1	432,42890	4346,324	,042	,370	,754
gdi_t2	428,69472	3722,374	,875	,833	,554
gdi_t3	448,10633	2575,924	,470	,620	,632
gdi_t4	429,80581	3973,762	,515	,426	,612
gdi_t5	425,93760	4303,194	,679	,637	,630
gdi_t6	435,17244	2919,103	,593	,695	,543



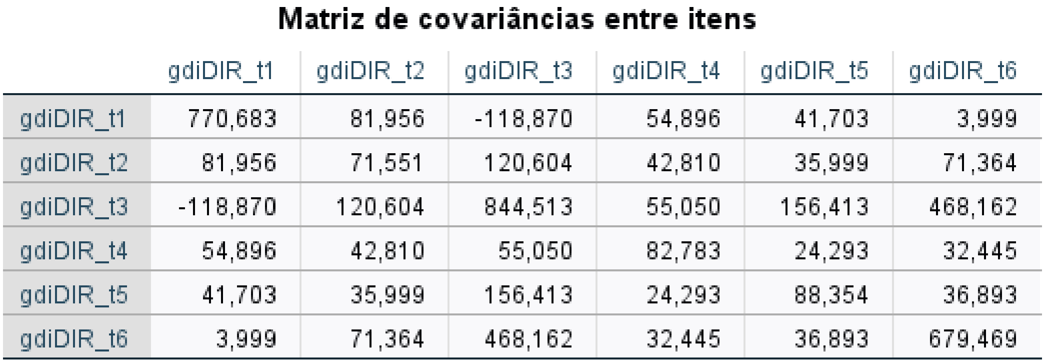
Matriz de covariâncias entre itens

	gdiESQ_t1	gdiESQ_t2	gdiESQ_t3	gdiESQ_t4	gdiESQ_t5	gdiESQ_t6
gdiESQ_t1	283,973	62,799	-98,790	50,025	15,690	42,357
gdiESQ_t2	62,799	198,117	240,173	110,151	63,189	254,558
gdiESQ_t3	-98,790	240,173	1044,948	270,703	72,543	358,263
gdiESQ_t4	50,025	110,151	270,703	301,205	80,684	157,526
gdiESQ_t5	15,690	63,189	72,543	80,684	38,079	69,700
gdiESQ_t6	42,357	254,558	358,263	157,526	69,700	446,163



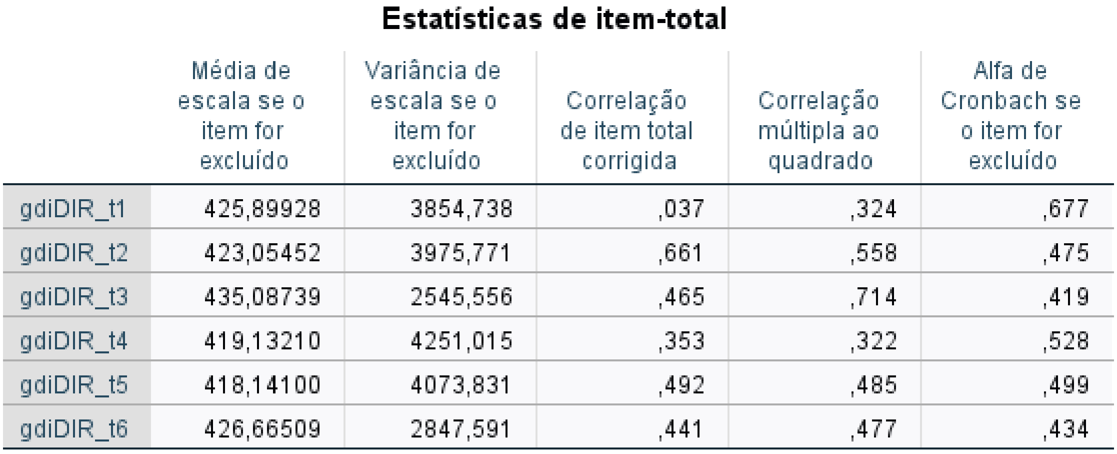
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
gdiESQ_t1	438,95853	5383,494	,058	,458	,779
gdiESQ_t2	434,33492	4151,770	,806	,924	,613
gdiESQ_t3	461,12527	3080,893	,470	,631	,736
gdiESQ_t4	440,47952	4172,242	,597	,800	,647
gdiESQ_t5	433,73419	5169,937	,680	,872	,700
gdiESQ_t6	443,67980	3600,656	,696	,821	,602



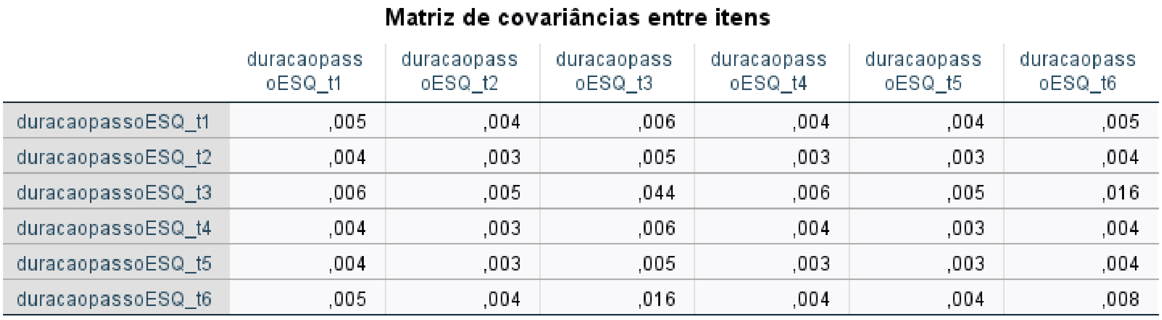
Matriz de covariâncias entre itens

	gdiDIR_t1	gdiDIR_t2	gdiDIR_t3	gdiDIR_t4	gdiDIR_t5	gdiDIR_t6
gdiDIR_t1	770,683	81,956	-118,870	54,896	41,703	3,999
gdiDIR_t2	81,956	71,551	120,604	42,810	35,999	71,364
gdiDIR_t3	-118,870	120,604	844,513	55,050	156,413	468,162
gdiDIR_t4	54,896	42,810	55,050	82,783	24,293	32,445
gdiDIR_t5	41,703	35,999	156,413	24,293	88,354	36,893
gdiDIR_t6	3,999	71,364	468,162	32,445	36,893	679,469



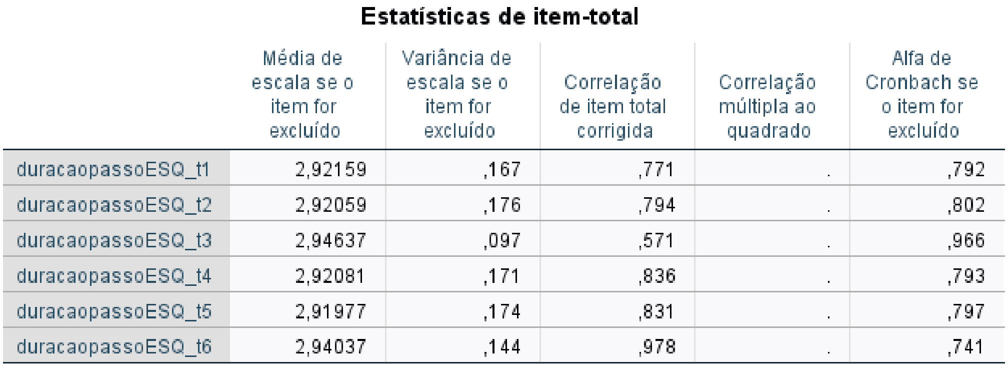
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
gdiDIR_t1	425,89928	3854,738	,037	,324	,677
gdiDIR_t2	423,05452	3975,771	,661	,558	,475
gdiDIR_t3	435,08739	2545,556	,465	,714	,419
gdiDIR_t4	419,13210	4251,015	,353	,322	,528
gdiDIR_t5	418,14100	4073,831	,492	,485	,499
gdiDIR_t6	426,66509	2847,591	,441	,477	,434



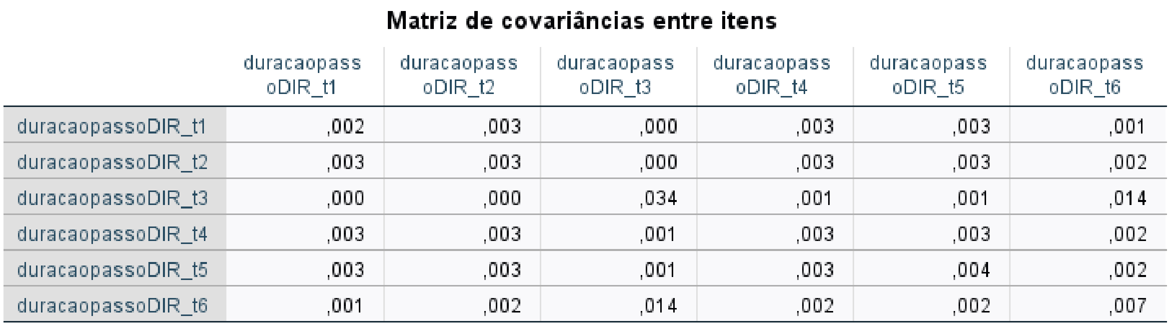
Matriz de covariâncias entre itens

	duracaopassoESQ_t1	duracaopassoESQ_t2	duracaopassoESQ_t3	duracaopassoESQ_t4	duracaopassoESQ_t5	duracaopassoESQ_t6
duracaopassoESQ_t1	,005	,004	,006	,004	,004	,005
duracaopassoESQ_t2	,004	,003	,005	,003	,003	,004
duracaopassoESQ_t3	,006	,005	,044	,006	,005	,016
duracaopassoESQ_t4	,004	,003	,006	,004	,003	,004
duracaopassoESQ_t5	,004	,003	,005	,003	,003	,004
duracaopassoESQ_t6	,005	,004	,016	,004	,004	,008



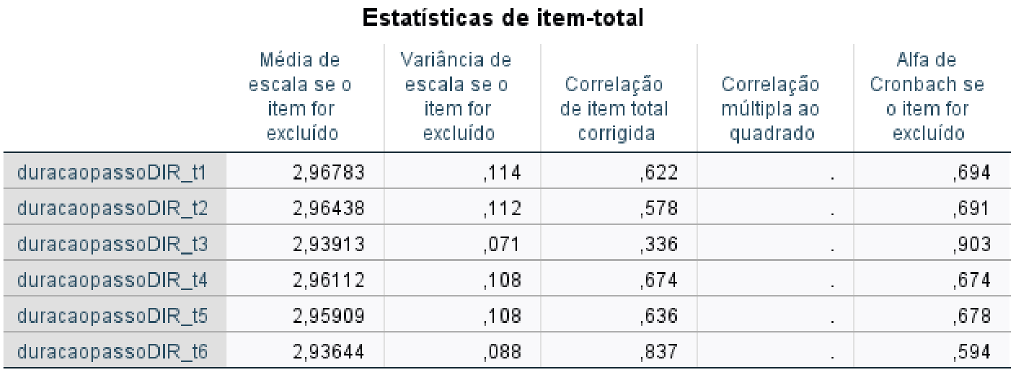
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
duracaopassoESQ_t1	2,92159	,167	,771	.	,792
duracaopassoESQ_t2	2,92059	,176	,794	.	,802
duracaopassoESQ_t3	2,94637	,097	,571	.	,966
duracaopassoESQ_t4	2,92081	,171	,836	.	,793
duracaopassoESQ_t5	2,91977	,174	,831	.	,797
duracaopassoESQ_t6	2,94037	,144	,978	.	,741



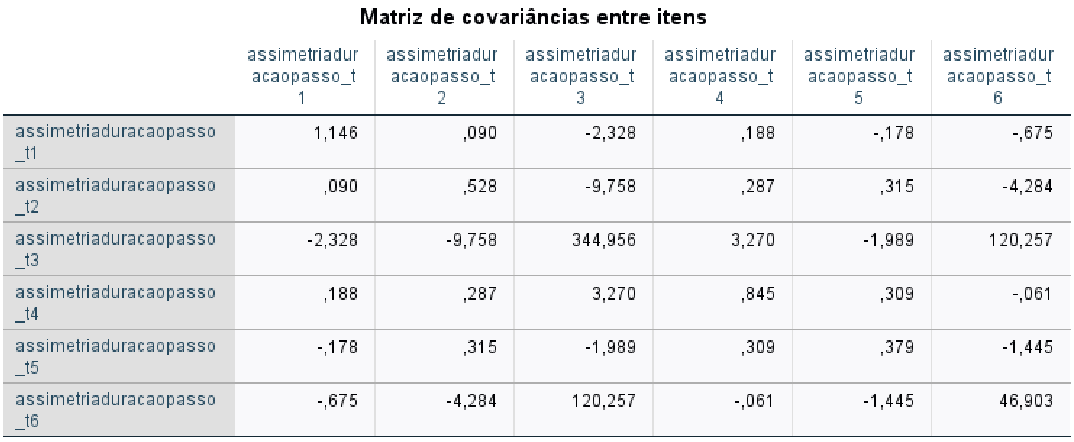
Matriz de covariâncias entre itens

	duracaopassoDIR_t1	duracaopassoDIR_t2	duracaopassoDIR_t3	duracaopassoDIR_t4	duracaopassoDIR_t5	duracaopassoDIR_t6
duracaopassoDIR_t1	,002	,003	,000	,003	,003	,001
duracaopassoDIR_t2	,003	,003	,000	,003	,003	,002
duracaopassoDIR_t3	,000	,000	,034	,001	,001	,014
duracaopassoDIR_t4	,003	,003	,001	,003	,003	,002
duracaopassoDIR_t5	,003	,003	,001	,003	,004	,002
duracaopassoDIR_t6	,001	,002	,014	,002	,002	,007



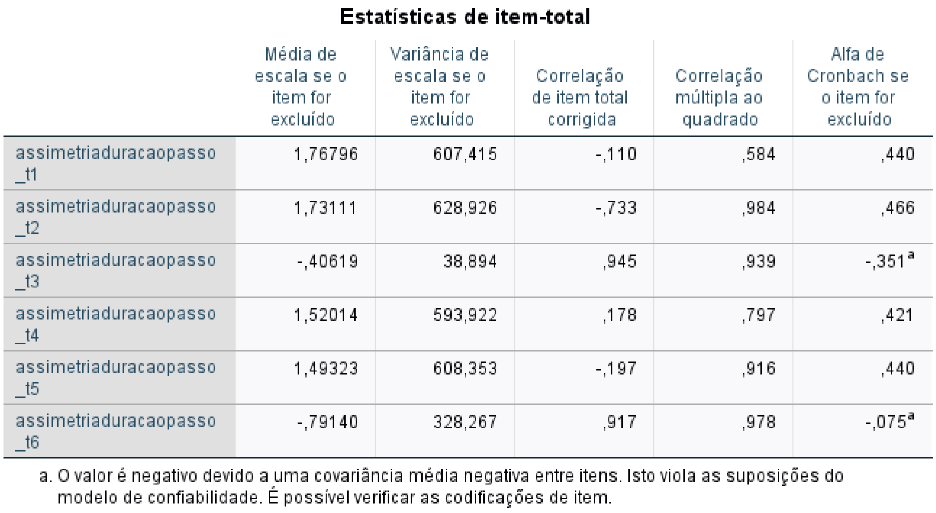
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
duracaopassoDIR_t1	2,96783	,114	,622	.	,694
duracaopassoDIR_t2	2,96438	,112	,578	.	,691
duracaopassoDIR_t3	2,93913	,071	,336	.	,903
duracaopassoDIR_t4	2,96112	,108	,674	.	,674
duracaopassoDIR_t5	2,95909	,108	,636	.	,678
duracaopassoDIR_t6	2,93644	,088	,837	.	,594



Matriz de covariâncias entre itens

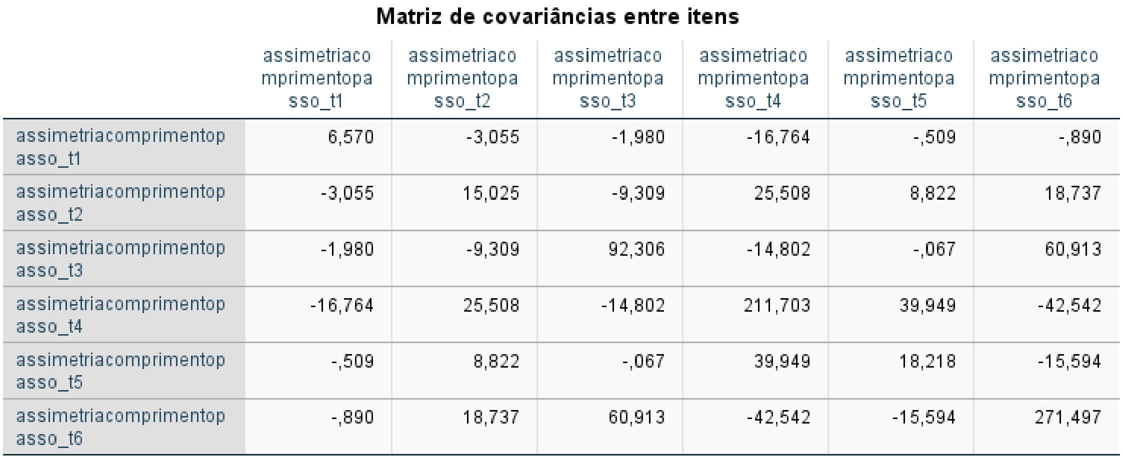
	assimetriaduracaopasso_t1	assimetriaduracaopasso_t2	assimetriaduracaopasso_t3	assimetriaduracaopasso_t4	assimetriaduracaopasso_t5	assimetriaduracaopasso_t6
assimetriaduracaopasso_t1	1,146	,090	-2,328	,188	-,178	-,675
assimetriaduracaopasso_t2	,090	,528	-9,758	,287	,315	-4,284
assimetriaduracaopasso_t3	-2,328	-9,758	344,956	3,270	-1,989	120,257
assimetriaduracaopasso_t4	,188	,287	3,270	,845	,309	-,061
assimetriaduracaopasso_t5	-,178	,315	-1,989	,309	,379	-1,445
assimetriaduracaopasso_t6	-,675	-4,284	120,257	-,061	-1,445	46,903



Estatísticas de item-total

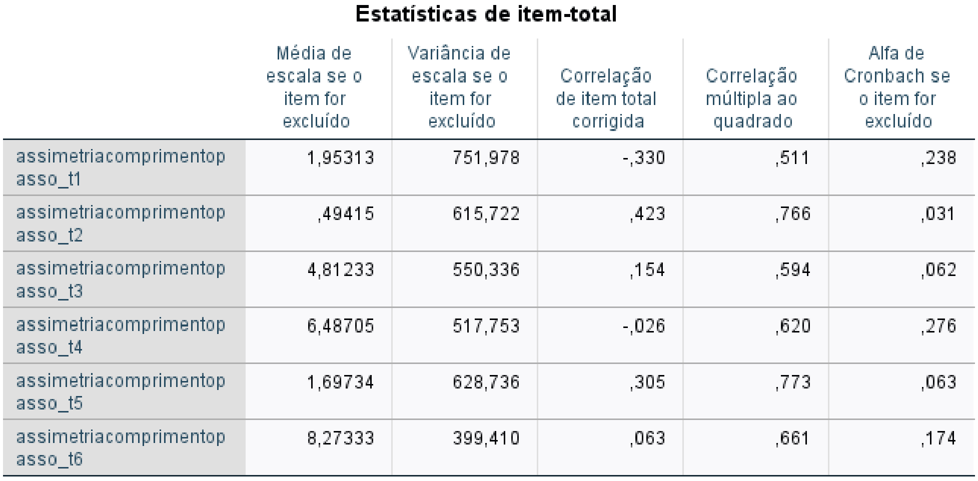
	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
assimetriaduracaopasso_t1	1,76796	607,415	-,110	,584	,440
assimetriaduracaopasso_t2	1,73111	628,926	-,733	,984	,466
assimetriaduracaopasso_t3	-,40619	38,894	,945	,939	-,351[a]
assimetriaduracaopasso_t4	1,52014	593,922	,178	,797	,421
assimetriaduracaopasso_t5	1,49323	608,353	-,197	,916	,440
assimetriaduracaopasso_t6	-,79140	328,267	,917	,978	-,075[a]

a. O valor é negativo devido a uma covariância média negativa entre itens. Isto viola as suposições do modelo de confiabilidade. É possível verificar as codificações de item.



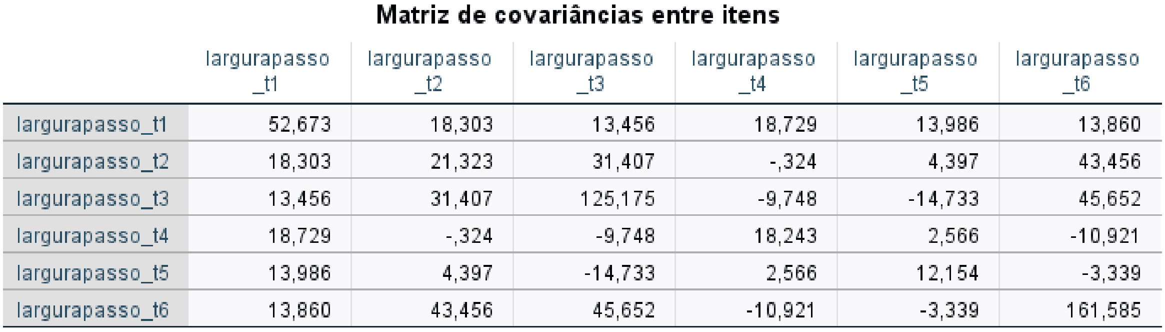
Matriz de covariâncias entre itens

	assimetriacomprimentopasso_t1	assimetriacomprimentopasso_t2	assimetriacomprimentopasso_t3	assimetriacomprimentopasso_t4	assimetriacomprimentopasso_t5	assimetriacomprimentopasso_t6
assimetriacomprimentopasso_t1	6,570	-3,055	-1,980	-16,764	-,509	-,890
assimetriacomprimentopasso_t2	-3,055	15,025	-9,309	25,508	8,822	18,737
assimetriacomprimentopasso_t3	-1,980	-9,309	92,306	-14,802	-,067	60,913
assimetriacomprimentopasso_t4	-16,764	25,508	-14,802	211,703	39,949	-42,542
assimetriacomprimentopasso_t5	-,509	8,822	-,067	39,949	18,218	-15,594
assimetriacomprimentopasso_t6	-,890	18,737	60,913	-42,542	-15,594	271,497



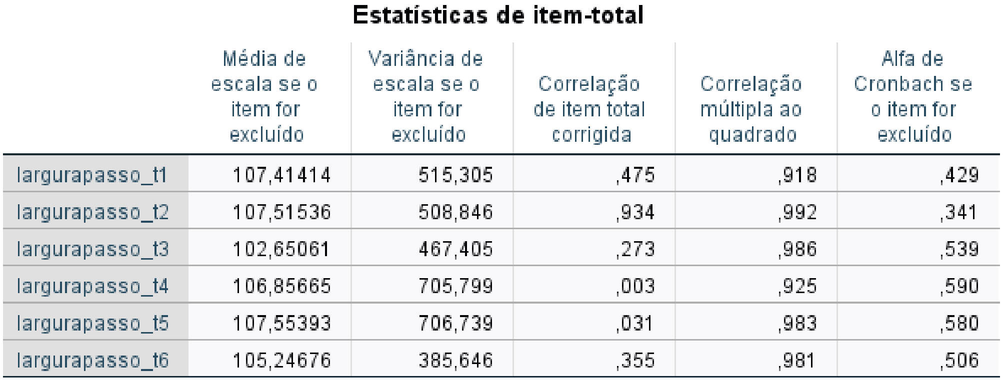
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
assimetriacomprimentopasso_t1	1,95313	751,978	-,330	,511	,238
assimetriacomprimentopasso_t2	,49415	615,722	,423	,766	,031
assimetriacomprimentopasso_t3	4,81233	550,336	,154	,594	,062
assimetriacomprimentopasso_t4	6,48705	517,753	-,026	,620	,276
assimetriacomprimentopasso_t5	1,69734	628,736	,305	,773	,063
assimetriacomprimentopasso_t6	8,27333	399,410	,063	,661	,174



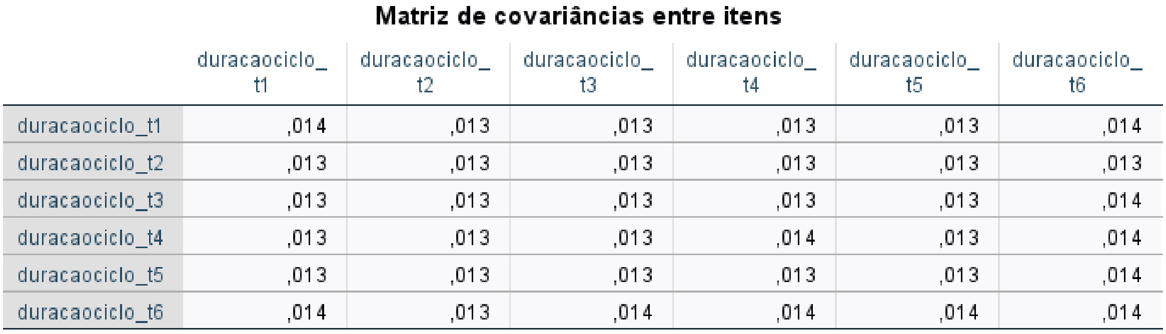
Matriz de covariâncias entre itens

	largurapasso_t1	largurapasso_t2	largurapasso_t3	largurapasso_t4	largurapasso_t5	largurapasso_t6
largurapasso_t1	52,673	18,303	13,456	18,729	13,986	13,860
largurapasso_t2	18,303	21,323	31,407	-,324	4,397	43,456
largurapasso_t3	13,456	31,407	125,175	-9,748	-14,733	45,652
largurapasso_t4	18,729	-,324	-9,748	18,243	2,566	-10,921
largurapasso_t5	13,986	4,397	-14,733	2,566	12,154	-3,339
largurapasso_t6	13,860	43,456	45,652	-10,921	-3,339	161,585



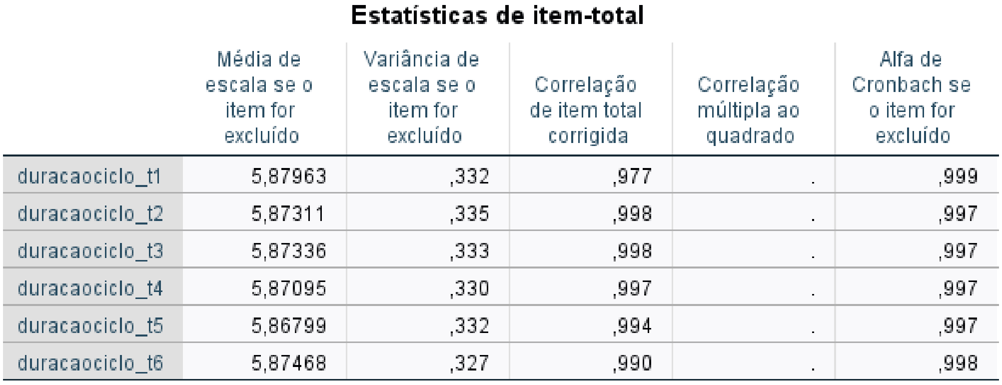
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
largurapasso_t1	107,41414	515,305	,475	,918	,429
largurapasso_t2	107,51536	508,846	,934	,992	,341
largurapasso_t3	102,65061	467,405	,273	,986	,539
largurapasso_t4	106,85665	705,799	,003	,925	,590
largurapasso_t5	107,55393	706,739	,031	,983	,580
largurapasso_t6	105,24676	385,646	,355	,981	,506



Matriz de covariâncias entre itens

	duracaociclo_t1	duracaociclo_t2	duracaociclo_t3	duracaociclo_t4	duracaociclo_t5	duracaociclo_t6
duracaociclo_t1	,014	,013	,013	,013	,013	,014
duracaociclo_t2	,013	,013	,013	,013	,013	,013
duracaociclo_t3	,013	,013	,013	,013	,013	,014
duracaociclo_t4	,013	,013	,013	,014	,013	,014
duracaociclo_t5	,013	,013	,013	,013	,013	,014
duracaociclo_t6	,014	,013	,014	,014	,014	,014

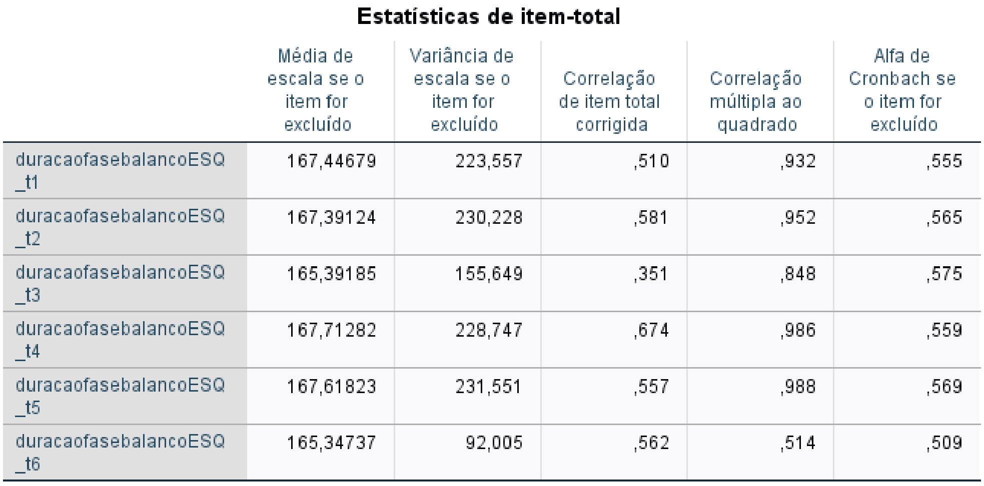


Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
duracaociclo_t1	5,87963	,332	,977	.	,999
duracaociclo_t2	5,87311	,335	,998	.	,997
duracaociclo_t3	5,87336	,333	,998	.	,997
duracaociclo_t4	5,87095	,330	,997	.	,997
duracaociclo_t5	5,86799	,332	,994	.	,997
duracaociclo_t6	5,87468	,327	,990	.	,998

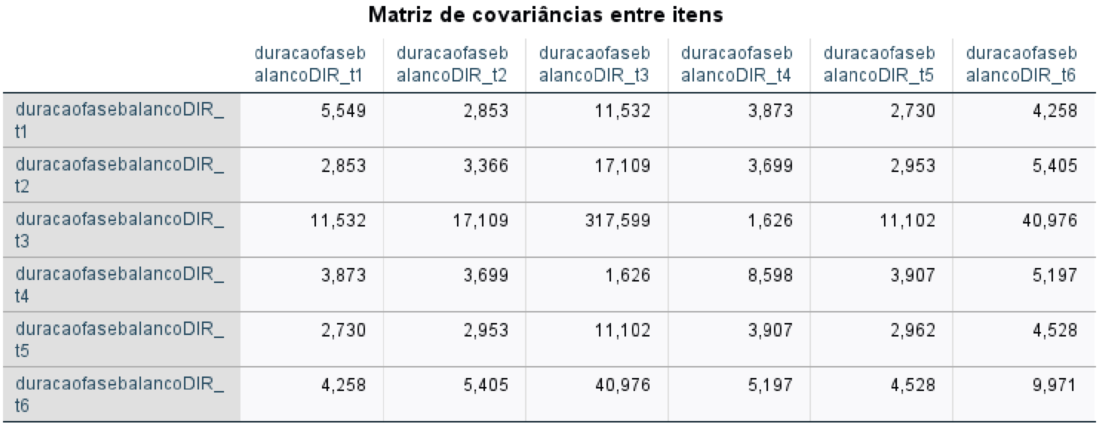
Matriz de covariâncias entre itens

	duracaofasebalancoESQ_t1	duracaofasebalancoESQ_t2	duracaofasebalancoESQ_t3	duracaofasebalancoESQ_t4	duracaofasebalancoESQ_t5	duracaofasebalancoESQ_t6
duracaofasebalancoESQ_t1	4,061	2,610	,791	2,553	2,686	6,726
duracaofasebalancoESQ_t2	2,610	2,168	2,031	1,796	1,988	4,553
duracaofasebalancoESQ_t3	,791	2,031	44,325	1,985	,390	23,991
duracaofasebalancoESQ_t4	2,553	1,796	1,985	1,851	1,908	5,634
duracaofasebalancoESQ_t5	2,686	1,988	,390	1,908	2,122	5,367
duracaofasebalancoESQ_t6	6,726	4,553	23,991	5,634	5,367	73,805



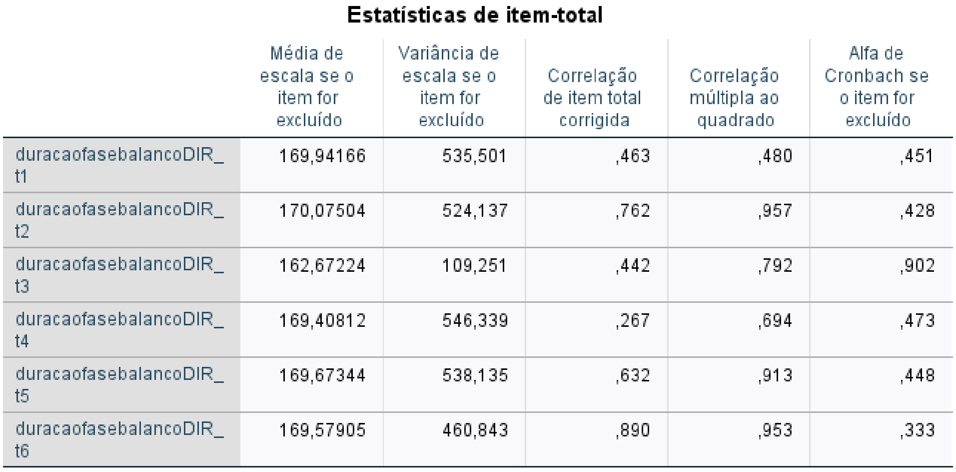
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
duracaofasebalancoESQ_t1	167,44679	223,557	,510	,932	,555
duracaofasebalancoESQ_t2	167,39124	230,228	,581	,952	,565
duracaofasebalancoESQ_t3	165,39185	155,649	,351	,848	,575
duracaofasebalancoESQ_t4	167,71282	228,747	,674	,986	,559
duracaofasebalancoESQ_t5	167,61823	231,551	,557	,988	,569
duracaofasebalancoESQ_t6	165,34737	92,005	,562	,514	,509



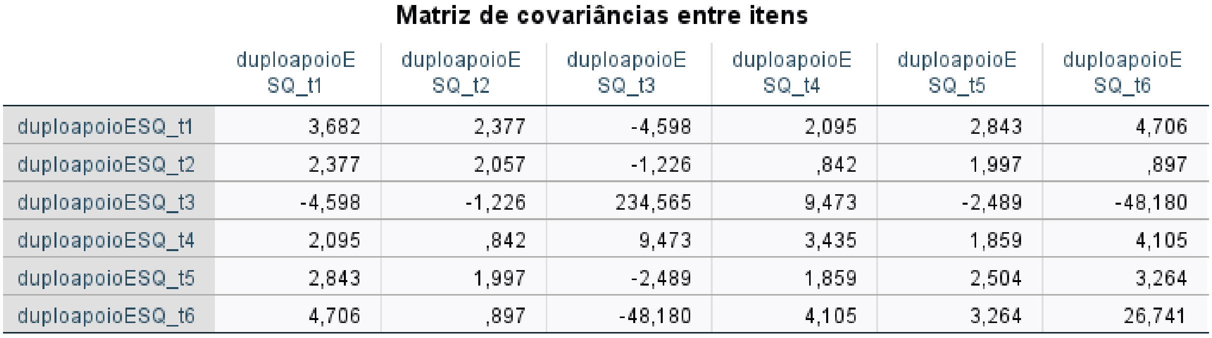
Matriz de covariâncias entre itens

	duracaofasebalancoDIR_t1	duracaofasebalancoDIR_t2	duracaofasebalancoDIR_t3	duracaofasebalancoDIR_t4	duracaofasebalancoDIR_t5	duracaofasebalancoDIR_t6
duracaofasebalancoDIR_t1	5,549	2,853	11,532	3,873	2,730	4,258
duracaofasebalancoDIR_t2	2,853	3,366	17,109	3,699	2,953	5,405
duracaofasebalancoDIR_t3	11,532	17,109	317,599	1,626	11,102	40,976
duracaofasebalancoDIR_t4	3,873	3,699	1,626	8,598	3,907	5,197
duracaofasebalancoDIR_t5	2,730	2,953	11,102	3,907	2,962	4,528
duracaofasebalancoDIR_t6	4,258	5,405	40,976	5,197	4,528	9,971



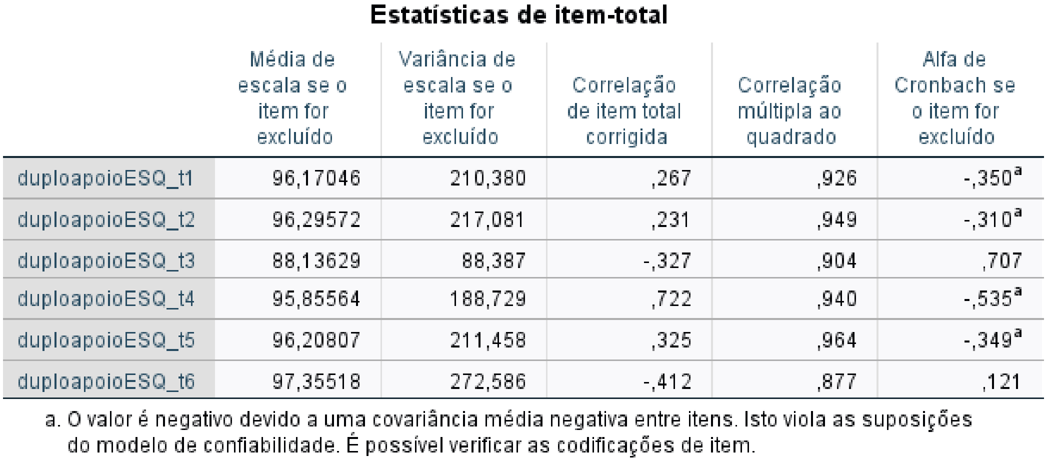
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
duracaofasebalancoDIR_t1	169,94166	535,501	,463	,480	,451
duracaofasebalancoDIR_t2	170,07504	524,137	,762	,957	,428
duracaofasebalancoDIR_t3	162,67224	109,251	,442	,792	,902
duracaofasebalancoDIR_t4	169,40812	546,339	,267	,694	,473
duracaofasebalancoDIR_t5	169,67344	538,135	,632	,913	,448
duracaofasebalancoDIR_t6	169,57905	460,843	,890	,953	,333



Matriz de covariâncias entre itens

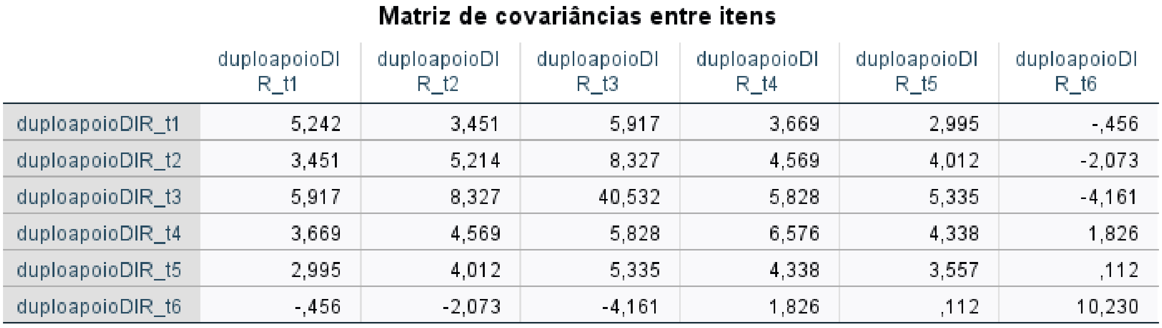
	duploapoioESQ_t1	duploapoioESQ_t2	duploapoioESQ_t3	duploapoioESQ_t4	duploapoioESQ_t5	duploapoioESQ_t6
duploapoioESQ_t1	3,682	2,377	-4,598	2,095	2,843	4,706
duploapoioESQ_t2	2,377	2,057	-1,226	,842	1,997	,897
duploapoioESQ_t3	-4,598	-1,226	234,565	9,473	-2,489	-48,180
duploapoioESQ_t4	2,095	,842	9,473	3,435	1,859	4,105
duploapoioESQ_t5	2,843	1,997	-2,489	1,859	2,504	3,264
duploapoioESQ_t6	4,706	,897	-48,180	4,105	3,264	26,741



Estatísticas de item-total

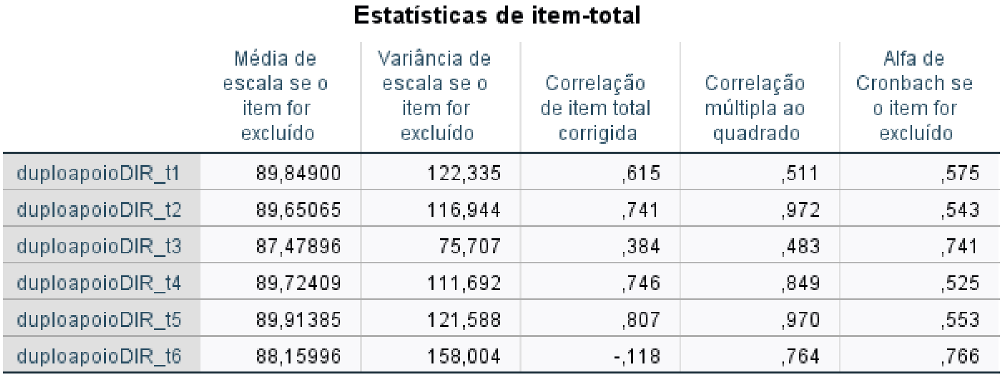
	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
duploapoioESQ_t1	96,17046	210,380	,267	,926	-,350[a]
duploapoioESQ_t2	96,29572	217,081	,231	,949	-,310[a]
duploapoioESQ_t3	88,13629	88,387	-,327	,904	,707
duploapoioESQ_t4	95,85564	188,729	,722	,940	-,535[a]
duploapoioESQ_t5	96,20807	211,458	,325	,964	-,349[a]
duploapoioESQ_t6	97,35518	272,586	-,412	,877	,121

a. O valor é negativo devido a uma covariância média negativa entre itens. Isto viola as suposições do modelo de confiabilidade. É possível verificar as codificações de item.



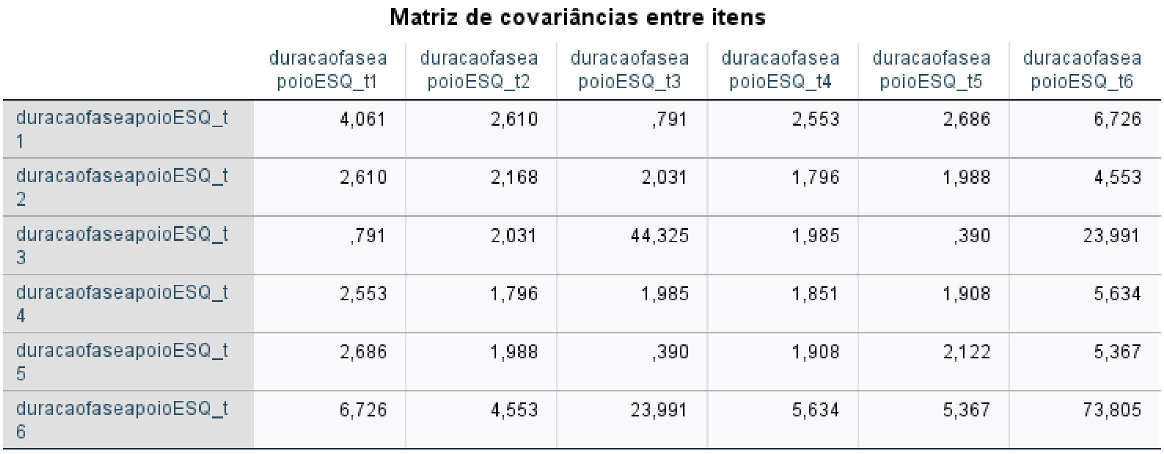
Matriz de covariâncias entre itens

	duploapoioDIR_t1	duploapoioDIR_t2	duploapoioDIR_t3	duploapoioDIR_t4	duploapoioDIR_t5	duploapoioDIR_t6
duploapoioDIR_t1	5,242	3,451	5,917	3,669	2,995	-,456
duploapoioDIR_t2	3,451	5,214	8,327	4,569	4,012	-2,073
duploapoioDIR_t3	5,917	8,327	40,532	5,828	5,335	-4,161
duploapoioDIR_t4	3,669	4,569	5,828	6,576	4,338	1,826
duploapoioDIR_t5	2,995	4,012	5,335	4,338	3,557	,112
duploapoioDIR_t6	-,456	-2,073	-4,161	1,826	,112	10,230



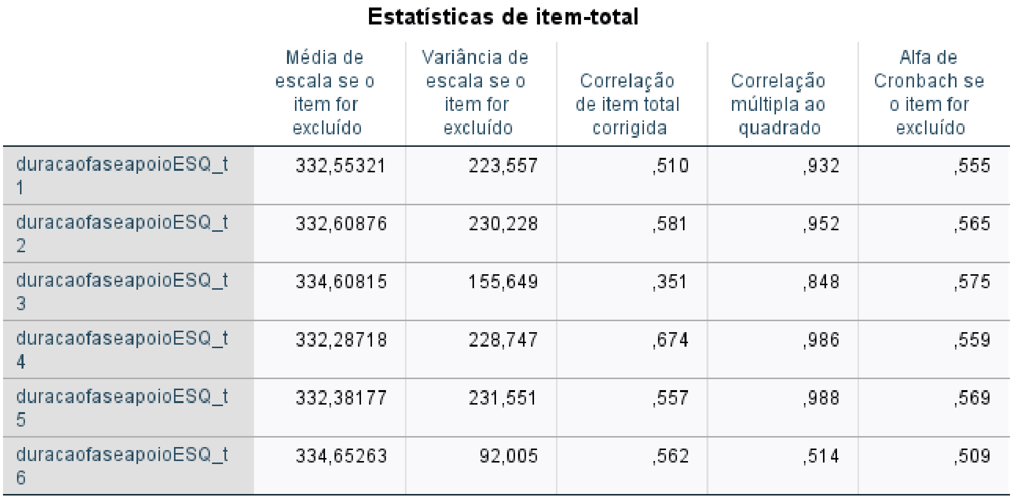
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
duploapoioDIR_t1	89,84900	122,335	,615	,511	,575
duploapoioDIR_t2	89,65065	116,944	,741	,972	,543
duploapoioDIR_t3	87,47896	75,707	,384	,483	,741
duploapoioDIR_t4	89,72409	111,692	,746	,849	,525
duploapoioDIR_t5	89,91385	121,588	,807	,970	,553
duploapoioDIR_t6	88,15996	158,004	-,118	,764	,766



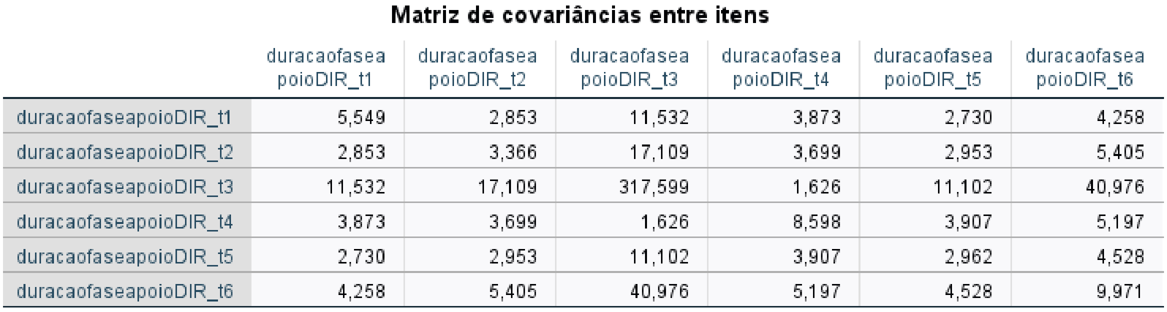
Matriz de covariâncias entre itens

	duracaofaseapoioESQ_t1	duracaofaseapoioESQ_t2	duracaofaseapoioESQ_t3	duracaofaseapoioESQ_t4	duracaofaseapoioESQ_t5	duracaofaseapoioESQ_t6
duracaofaseapoioESQ_t1	4,061	2,610	,791	2,553	2,686	6,726
duracaofaseapoioESQ_t2	2,610	2,168	2,031	1,796	1,988	4,553
duracaofaseapoioESQ_t3	,791	2,031	44,325	1,985	,390	23,991
duracaofaseapoioESQ_t4	2,553	1,796	1,985	1,851	1,908	5,634
duracaofaseapoioESQ_t5	2,686	1,988	,390	1,908	2,122	5,367
duracaofaseapoioESQ_t6	6,726	4,553	23,991	5,634	5,367	73,805



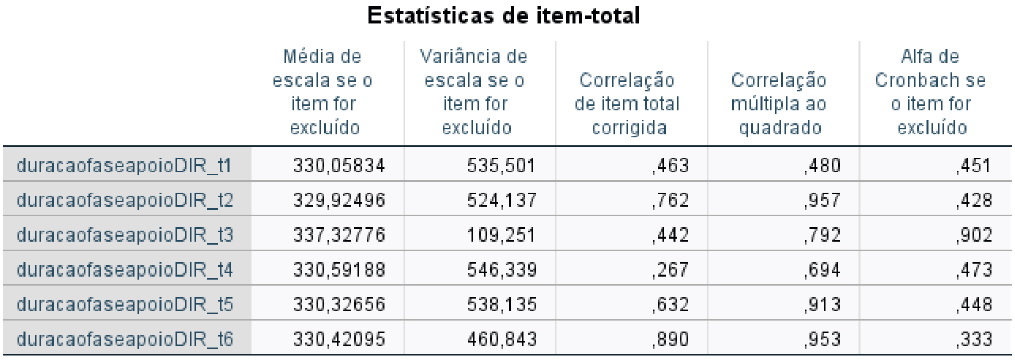
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
duracaofaseapoioESQ_t1	332,55321	223,557	,510	,932	,555
duracaofaseapoioESQ_t2	332,60876	230,228	,581	,952	,565
duracaofaseapoioESQ_t3	334,60815	155,649	,351	,848	,575
duracaofaseapoioESQ_t4	332,28718	228,747	,674	,986	,559
duracaofaseapoioESQ_t5	332,38177	231,551	,557	,988	,569
duracaofaseapoioESQ_t6	334,65263	92,005	,562	,514	,509



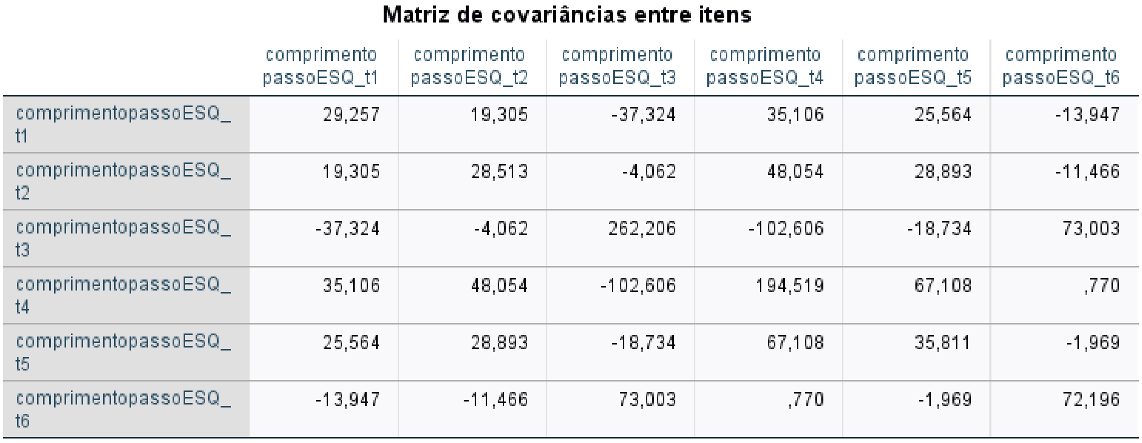
Matriz de covariâncias entre itens

	duracaofaseapoioDIR_t1	duracaofaseapoioDIR_t2	duracaofaseapoioDIR_t3	duracaofaseapoioDIR_t4	duracaofaseapoioDIR_t5	duracaofaseapoioDIR_t6
duracaofaseapoioDIR_t1	5,549	2,853	11,532	3,873	2,730	4,258
duracaofaseapoioDIR_t2	2,853	3,366	17,109	3,699	2,953	5,405
duracaofaseapoioDIR_t3	11,532	17,109	317,599	1,626	11,102	40,976
duracaofaseapoioDIR_t4	3,873	3,699	1,626	8,598	3,907	5,197
duracaofaseapoioDIR_t5	2,730	2,953	11,102	3,907	2,962	4,528
duracaofaseapoioDIR_t6	4,258	5,405	40,976	5,197	4,528	9,971



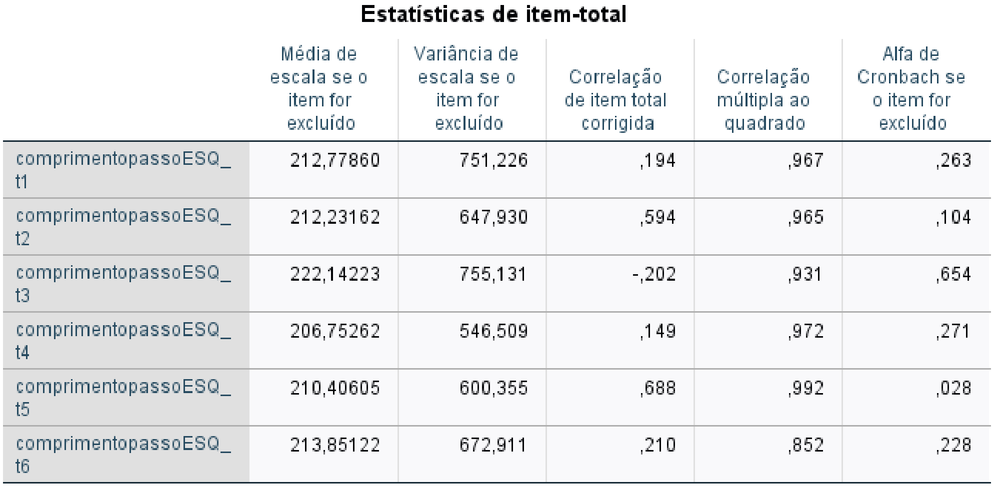
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
duracaofaseapoioDIR_t1	330,05834	535,501	,463	,480	,451
duracaofaseapoioDIR_t2	329,92496	524,137	,762	,957	,428
duracaofaseapoioDIR_t3	337,32776	109,251	,442	,792	,902
duracaofaseapoioDIR_t4	330,59188	546,339	,267	,694	,473
duracaofaseapoioDIR_t5	330,32656	538,135	,632	,913	,448
duracaofaseapoioDIR_t6	330,42095	460,843	,890	,953	,333



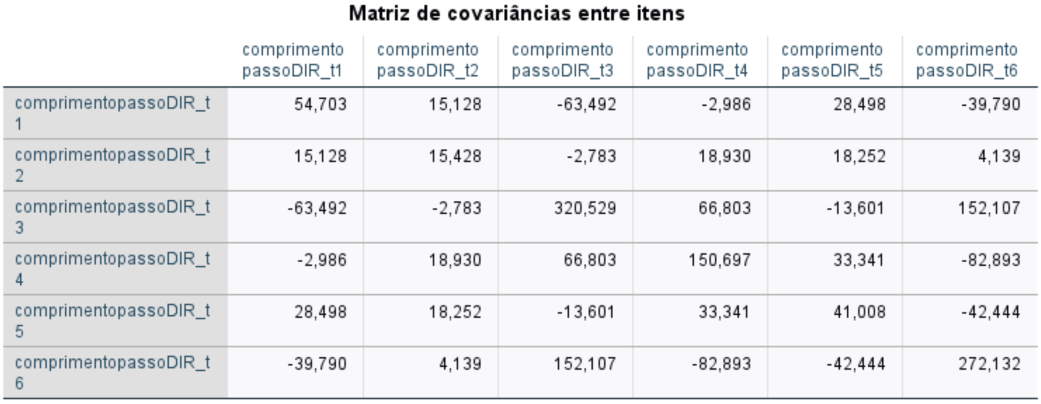
Matriz de covariâncias entre itens

	comprimentopassoESQ_t1	comprimentopassoESQ_t2	comprimentopassoESQ_t3	comprimentopassoESQ_t4	comprimentopassoESQ_t5	comprimentopassoESQ_t6
comprimentopassoESQ_t1	29,257	19,305	-37,324	35,106	25,564	-13,947
comprimentopassoESQ_t2	19,305	28,513	-4,062	48,054	28,893	-11,466
comprimentopassoESQ_t3	-37,324	-4,062	262,206	-102,606	-18,734	73,003
comprimentopassoESQ_t4	35,106	48,054	-102,606	194,519	67,108	,770
comprimentopassoESQ_t5	25,564	28,893	-18,734	67,108	35,811	-1,969
comprimentopassoESQ_t6	-13,947	-11,466	73,003	,770	-1,969	72,196



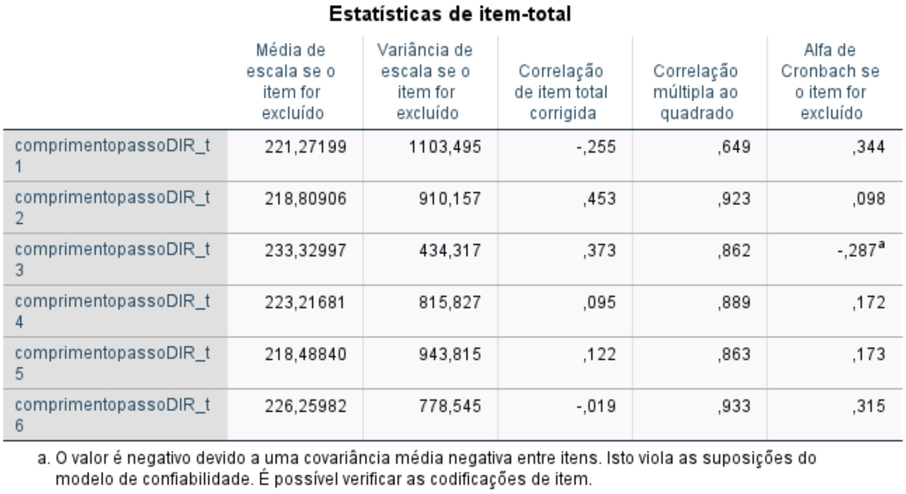
Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
comprimentopassoESQ_t1	212,77860	751,226	,194	,967	,263
comprimentopassoESQ_t2	212,23162	647,930	,594	,965	,104
comprimentopassoESQ_t3	222,14223	755,131	-,202	,931	,654
comprimentopassoESQ_t4	206,75262	546,509	,149	,972	,271
comprimentopassoESQ_t5	210,40605	600,355	,688	,992	,028
comprimentopassoESQ_t6	213,85122	672,911	,210	,852	,228



Matriz de covariâncias entre itens

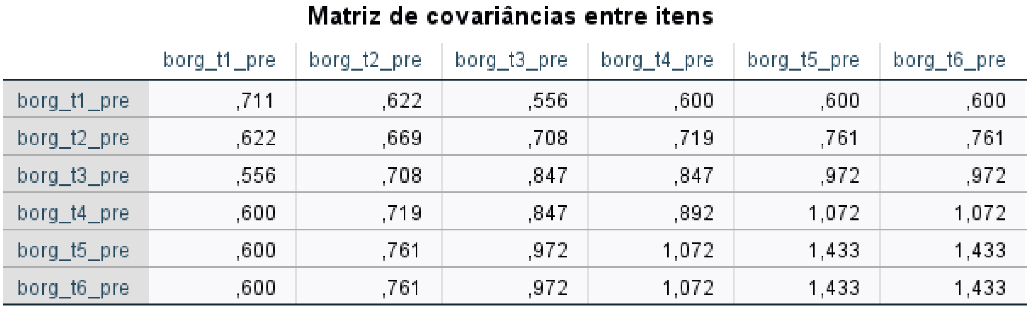
	comprimento passoDIR_t1	comprimento passoDIR_t2	comprimento passoDIR_t3	comprimento passoDIR_t4	comprimento passoDIR_t5	comprimento passoDIR_t6
comprimentopassoDIR_t 1	54,703	15,128	-63,492	-2,986	28,498	-39,790
comprimentopassoDIR_t 2	15,128	15,428	-2,783	18,930	18,252	4,139
comprimentopassoDIR_t 3	-63,492	-2,783	320,529	66,803	-13,601	152,107
comprimentopassoDIR_t 4	-2,986	18,930	66,803	150,697	33,341	-82,893
comprimentopassoDIR_t 5	28,498	18,252	-13,601	33,341	41,008	-42,444
comprimentopassoDIR_t 6	-39,790	4,139	152,107	-82,893	-42,444	272,132



Estatísticas de item-total

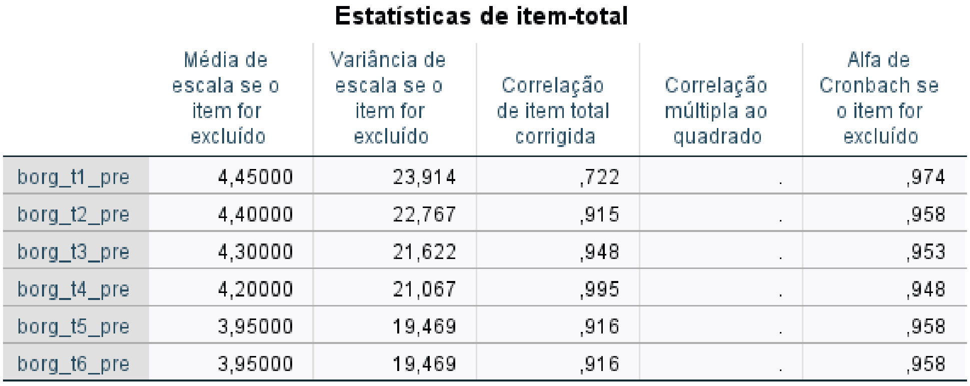
	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
comprimentopassoDIR_t 1	221,27199	1103,495	-,255	,649	,344
comprimentopassoDIR_t 2	218,80906	910,157	,453	,923	,098
comprimentopassoDIR_t 3	233,32997	434,317	,373	,862	-,287[a]
comprimentopassoDIR_t 4	223,21681	815,827	,095	,889	,172
comprimentopassoDIR_t 5	218,48840	943,815	,122	,863	,173
comprimentopassoDIR_t 6	226,25982	778,545	-,019	,933	,315

a. O valor é negativo devido a uma covariância média negativa entre itens. Isto viola as suposições do modelo de confiabilidade. É possível verificar as codificações de item.



Matriz de covariâncias entre itens

	borg_t1_pre	borg_t2_pre	borg_t3_pre	borg_t4_pre	borg_t5_pre	borg_t6_pre
borg_t1_pre	,711	,622	,556	,600	,600	,600
borg_t2_pre	,622	,669	,708	,719	,761	,761
borg_t3_pre	,556	,708	,847	,847	,972	,972
borg_t4_pre	,600	,719	,847	,892	1,072	1,072
borg_t5_pre	,600	,761	,972	1,072	1,433	1,433
borg_t6_pre	,600	,761	,972	1,072	1,433	1,433



Estatísticas de item-total

	Média de escala se o item for excluído	Variância de escala se o item for excluído	Correlação de item total corrigida	Correlação múltipla ao quadrado	Alfa de Cronbach se o item for excluído
borg_t1_pre	4,45000	23,914	,722	.	,974
borg_t2_pre	4,40000	22,767	,915	.	,958
borg_t3_pre	4,30000	21,622	,948	.	,953
borg_t4_pre	4,20000	21,067	,995	.	,948
borg_t5_pre	3,95000	19,469	,916	.	,958
borg_t6_pre	3,95000	19,469	,916	.	,958

7.7. Spearman’s rank correlation test detailed results

Table 6

Spearman's Rank Correlation Statistics

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. cadence_M (steps per minute)																			
2. speed_M (meters per second)	,873** 0,000454615																		
3. gdi_M (%)	0,036363636 0,915468317	-0,14545 0,669579																	
4. gdi_L_M (%)	-0,063636364 0,852539073	-0,2 0,555445	,873** 0,000454615																
5. gdi_R_M (%)	0,090909091 0,790372738	-0,10909 0,749509	,982** 8,40307E-08	,845** 0,001045															
6. StepTime_L_M (seconds)	-,945** 1,1183E-05	-,873** 0,000455	0,063636364 0,852539073	0,127273 0,709215	0,027272727 0,936558448														
7. StepTime_R_M (seconds)	-0,6 0,051003261	-0,43636 0,179665	0,063636364 0,852539073	0,190909 0,573913	-0,063636364 0,852539073	0,436363636 0,179664877													
8. AssStepTime_M (%)	0,163636364 0,630685215	0,281818 0,401145	0,172727273 0,611542385	0,063636 0,852539	0,136363636 0,689309021	-0,3 0,370083122	0,536364 0,088953												
9. AssStepLength_M (%)	-0,318181818 0,340297614	-0,43636 0,179665	0,281818182 0,401144898	0,463636 0,150901	0,281818182 0,401144898	0,409090909 0,21154501	0,372727 0,258926	0,054545 0,873447											
10. StepWidth_M (centimeters)	-0,336363636 0,311824314	-0,34545 0,298089	-0,145454545 0,669578646	-0,22727 0,501536	-0,236363636 0,484091162	0,254545455 0,450036577	0,509091 0,109737	0,281818 0,401145	-0,25455 0,450037										
11. StrideTime_M (seconds)	-,991** 3,76257E-09	-,891** 0,000233	0,009090909 0,9788365	0,109091 0,749509	-0,027272727 0,936558448	,955** 4,9889E-06	0,554545 0,076652	-0,18182 0,592615	0,4 0,222868	0,254545 0,450037									
12. SwingTime_L_M (%)	0,172727273 0,611542385	0,354545 0,284693	-0,563636364 0,070951734	-,655* 0,028865	-,627* 0,038845254	-0,209090909 0,537220935	-0,05455 0,873447	-0,02727 0,936558	-0,39091 0,23454	0,009091 0,978837	-0,254545455 0,450036577								
13. SwingTime_R_M (%)	-0,445454545 0,169732605	-0,40909 0,211545	0,245454545 0,466922367	0,363636 0,271638	0,3 0,370083122	0,518181818 0,10249154	0,218182 0,519248	0,054545 0,873447	,682* 0,020843	-0,19091 0,573913	0,536363636 0,088953418	-,673* 0,023313							
14. DoubleSupportFraction_L_M (%)	0,572727273 0,065543053	,764** 0,006233	0,018181818 0,957685241	-0,01818 0,957685	0,1 0,769875	-0,454545455 0,160145437	-0,56364 0,070952	0,009091 0,978837	-0,33636 0,311824	-0,50909 0,109737	-0,563636364 0,070951734	0,190909 0,573913	-0,12727 0,709215						
15. DoubleSupportFraction_R_M (%)	0,354545455 0,284692741	0,381818 0,24656	0,436363636 0,179664877	0,554545 0,076652	0,436363636 0,179664877	-0,2 0,555445442	-0,05455 0,873447	0,136364 0,689309	0,509091 0,109737	-0,6 0,051003	-0,309090909 0,35502844	-0,04545 0,894427	0,227273 0,501536	0,509091 0,109737					
16. StanceTime_L_M (%)	-0,172727273 0,611542385	-0,35455 0,284693	0,563636364 0,070951734	,655* 0,028865	,627* 0,038845254	0,209090909 0,537220935	0,054545 0,873447	0,027273 0,936558	0,390909 0,23454	-0,00909 0,978837	0,254545455 0,450036577	-1,000**	,673* 0,023313	-0,19091 0,573913	0,045455 0,894427				
17. StanceTime_R_M (%)	-0,445454545 0,169732605	-0,40909 0,211545	0,245454545 0,466922367	0,363636 0,271638	0,3 0,370083122	0,518181818 0,10249154	0,218182 0,519248	0,054545 0,873447	,682* 0,020843	-0,19091 0,573913	0,536363636 0,088953418	-,673* 0,023313	1,000**	-0,12727 0,709215	0,227273 0,501536	,673* 0,023313			
18. StepLength_L_M (centimeters)	0,572727273 0,065543053	,764** 0,006233	0,018181818 0,957685241	-0,01818 0,957685	0,1 0,769875	-0,454545455 0,160145437	-0,56364 0,070952	0,009091 0,978837	-0,33636 0,311824	-0,50909 0,109737	-0,563636364 0,070951734	0,190909 0,573913	-0,12727 0,709215	1,000**	0,509091 0,109737	-0,19091 0,573913	-0,12727 0,709215		
19. StepLength_R_M (centimeters)	0,354545455 0,284692741	0,381818 0,24656	0,436363636 0,179664877	0,554545 0,076652	0,436363636 0,179664877	-0,2 0,555445442	-0,05455 0,873447	0,136364 0,689309	0,509091 0,109737	-0,6 0,051003	-0,309090909 0,35502844	-0,04545 0,894427	0,227273 0,501536	0,509091 0,109737	1,000**	0,045455 0,894427	0,227273 0,501536	0,509091 0,109737	
20. borg_pos_M (units)	-0,124261179 0,715845577	-0,06691 0,845031	-0,08602697 0,801430932	-0,14816 0,663748	0,004779276 0,988873141	0,019117104 0,955510349	0,081248 0,812288	0,353666 0,285973	-0,20073 0,553974	0,344108 0,300103	0,148157559 0,663747531	-0,52094 0,100356	0,315432 0,344719	-0,03823 0,911134	-0,49704 0,119838	0,520941 0,100356	0,315432 0,344719	-0,03823 0,911134	-0,49704 0,119838

$**P$< .01 (2 tailed); P< .05; n=11