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Dynamic Evaluation Method of Lower Limb Joint Alignment with Parallel Feet (MADAAMI-P): Content validation and Reproducibility

Maiane A. Amaral[1], Cláudia T Candotti[1], Isis J. R L Navarro[1*], Kaanda N. S Gontijo[1], Taís R. Fiegenbaum[1], Gabriela C. Santos[1], Jefferson F. Loss[1]

ORIGINAL ARTICLE

ABSTRACT

Neutral static alignment, normal movement and a satisfactory segmental interrelationship are described as significant factors in normal asymptomatic function and, when altered, increase the risk of lesions in the lower limbs. It is important to focus on the early identification of joint misalignments. Thus, the present study aims at developing, validating the content developed and confirming the reproducibility of the Dynamic Evaluation Method of Lower Limb Joint Alignment with Parallel Feet (MADAAMI-P), a simple video-based evaluation method using surface markers and a score sheet. The study was carried out in three stages: (1) the Dynamic Evaluation Method of Lower Limb Joint Alignment for dancers (MADAAMI) was adapted; (2) the content validity of the score sheet used in MADAAMI-P was checked; and (3) the intra- and inter-rater reproducibility were evaluated. Cohen's Kappa coefficient and the Intraclass Correlation Coefficient (ICC) were used in the statistical analysis to analyze the categories of the score sheet criteria and sum of the scores ($\alpha < 0.05$). The results showed that MADAAMI-P presents content validity satisfactory.

Keywords: evaluation; validation studies; joint instability.

INTRODUCTION

Alignment of the lower limb is considered neutral if the center of the hip-knee-ankle joints, coincides in the same vertical imaginary line, in the frontal plane (Saavedra & Espregueira-Mendes, 2014). In addition, to a good static alignment of the lower limb, a normal movement, i.e. a satisfactory segmental interrelationship, has been determined as one of the significant factors under normal asymptomatic function. Therefore, it has been suggested that abnormal movements and segmental interactions increase the risk of lower limb injury (Khamis, Dar, Peretz, & Yizhar, 2015), as well as increasing the risk of patellofemoral symptoms or instability (MAGEE, 2005). Thus, prevention is important and we highlight that the early identification of static and dynamic joint misalignments may help to diagnose these injuries.

In order to identify such misalignments, it is important that specific assessment tools are available for this purpose. Regarding dynamic joint alignment assessment, some studies use 3D camera systems or accelerometers (Khamis et al., 2015; Pohjola, Sayers, Mellifont, Mellifont, & Venojärvi, 2014; Shippen, 2011). However, they are unsuitable for use in clinical practice, because they require considerable space and personnel trained in the use of such systems, besides their high costs. Gontijo, Candotti, Feijó, Ribeiro and Loss (2017) suggested an evaluation method based on simple recording, with the aid of surface markers and a score sheet which allows the evaluation of the dynamic articular alignment in the lower limbs of dancers, considering the high prevalence of injuries in this population and the relationship of those injuries with joint misalignment.

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[1] *Universidade Federal do Rio Grande do Sul, Porto Alegre - Brasil*
* *Corresponding author*: Rua Felizardo, 750 – Jardim Botânico, Porto Alegre – RS- Brasil
Email: isisjlnavarro@gmail.com

This method, named MADAAMI (Gontijo et al., 2017) and later MADAAMI-II (Gontijo et al., 2018), allows quick and easy access and handling using basic equipment (camera, tripod and markers) and a score sheet. However, the method considers the characteristic positions and movements of classical ballet which makes it difficult to extrapolate to other populations.

Considering the importance of assessing joint alignment, not only as a means of providing basic information before some treatment or training, but also as a way of acting in the prevention of injuries that affect the activities of daily living (ADLs) of the general population, it was deemed necessary to adapt the MADAAMI. The sequence of movements performed during the test and the positioning of the feet of the individuals evaluated underwent adaptations. Therefore, the objective of the present study was to develop, validate the content developed and evaluate the reproducibility of the Dynamic Evaluation Method of Lower Limb Joint Alignment with Parallel Feet, then nominated by *MADAAMI-P*.

METHOD

This is a correlational ex-post-facto type study, characterized as a reliability study.

Participants

The sample size was calculated according to Sim and Wright (2005), assuming a null hypothesis of Kappa = 0.40; power of 80%; and the worse scenario of the proportion of positive ratings equivalent to 30%, to detect a Kappa = 0.70. Thus, a consecutive sample of fifty-two asymptomatic individuals aged between 19 and 33 years (25.2 ± 2.7), 65% women and 35% men, average weight (65.0 ± 7.5) kg, height (1.65 ± 0.06) m and body mass index (24.1 ±1.3) kg/m^2 participated in the present study.

Individuals who presented pain in the lower limbs at the time of the evaluation, as well as those who reported pain in the lower limbs during the evaluation week, were excluded. The study was approved by the Research Ethics Committee of the *Federal University of Rio Grande do Sul* (UFRGS) (CAAE: 58157016.0.0000.5347) and the individuals read and signed the Informed Consent Term (ICT).

Measures

Evaluation with MADAAMI-P requires a pre-prepared environment. This preparation consists of: (a) a plumb line hanging over a marked centerline on the floor; (b) three parallel reference lines marked on the ground at 10, 12 and 15 cm from the center line of the plumb line; (c) a digital Sony camera HDR-CX19 (Tokyo, Japan) positioned on a tripod at 1.75 m from the reference lines, with the center of its lens aligned with the plumb line. A metal measuring tape was used to align the center of the lens with the plumb line. The height of the tripod supporting the camera may initially be 0.5 m, varying according to the height of the individual to be evaluated, provided that the video clearly shows the lower limbs of the individual and the reference lines marked on the floor (Figure 1).

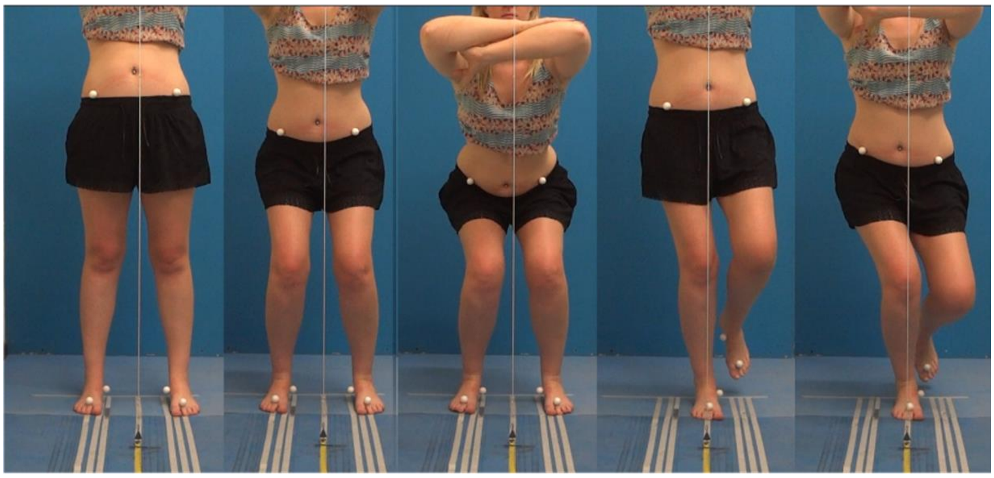


Figure 1. Representation of the movements evaluated by MADAAMI-P, as well as the evaluation environment (plumb line and demarcated lines on the ground) and surface markers for reference.

Participants completed a form with the following information: Age; Sex (F / M); Weight (kg); Height (cm). They also answered the questions: Do you have any injuries to lower limbs? If so, which one? Have you had regular physical activity for at least three months without interruption? If so, which one? How many times a week?

Procedures

The study consisted of three stages: (a) MADAAMI-P development, adapted from MADAAMI for ballet dancers; (b) content validation of the score sheet, based on analysis from six experts; and (c) evaluation of intra- and inter-rater reproducibility, from a consecutive sample.

(a) MADAAMI-P Development

As the name suggests, MADAAMI-P is designed to dynamically evaluate joint alignment and stability in the lower limbs from the video recordings. Its development consisted of the adaptation of MADAAMI-I and MADAAMI-II both developed to evaluate the dynamic joint alignment of the lower limbs of ballet dancers (Gontijo et al., 2017).

The adaptation process of the instrument consisted of adjustments of the environment, the protocol of evaluation of individuals and shooting plan; adaptation of the movements evaluated; and change in the scoring score sheet.

Regarding the adaptations of the environment and protocol of evaluation of the individuals, the position of the plumb line was modified, being placed in the center of the video, so that it is between the lower limbs of the individual to be evaluated. Regarding the protocol of evaluation, there was modification referring to the anatomical points of reference for the evaluation. In MADAAMI-P the palpated and marked points with the surface markers (white polystyrene pellets) in the subject to be evaluated are: anterior superior iliac spine (ASIS), navicular bone, and second metatarsal-phalangeal joint, all bilaterally. As for the alteration of the shooting plan of the sequence of movements, in MADAAMI-P the filming must be performed in the frontal plane, with the individual positioned with the feet parallel on the lines previously marked on the ground.

The sequence of MADAAMI-P movements was also adapted, being defined as: (1) a semi-flexion repetition of knees (semi-squatting) with parallel feet, in bipodal support; (2) a 90 ° repetition of kneeling (squatting) with parallel feet, in bipodal support; (3) a repetition of knee semi-flexion (semi-squatting) in right unipodal support; and (4) a repetition of knee semi-flexion (semi-squatting) in left unipodal support (Figure 1). When choosing the movements to be assessed, functionality, simplicity and ease of execution were guiding factors.

The analysis of the video containing the sequence of movements of MADAAMI-P is performed by filling out a scoring score sheet. In this sense, the last adaptation was the score sheet developed for MADAAMI-P, elaborated to score three basic criteria: (1) stabilization of the arch of the foot, (2) alignment and stabilization of the center of the knee with the ipsilateral foot and 3) pelvic alignment and stabilization. For each criterion a series of categories scored from 1 to 3 are presented, where 1 represents the worst aligned or stable execution, and 3 (or 2 in some criteria) the best alignment or stability. There is, therefore, a summation of points for each criterion evaluated and for each lower limb, as well as a final score, which the higher indicates a better joint alignment. Also, in the scoring chart, the movements evaluated in the MADAAMI-P sequence (knee flexion, knee flexion at 90 ° and knee flexion in unipodal support) were identified, divided into static and dynamic phases (Figure 3).

In order to facilitate the use of MADAAMI-P, a collection of video examples and their corresponding analysis have been included in the User's Manual, which can be requested from the authors.

(b) Content validation

Once the first version of MADAAMI-P was developed, we proceeded with the second stage of the study, the content validation. In this stage, six experts, four Physiotherapists and two

Physical Education Teachers, were invited. All the experts have at least 15 years of experience in postural evaluation in their respective areas and specialize in Human Movement Sciences and / or Kinesiology. These experts were responsible for evaluating the clarity and suitability of the score sheet of MADAAMI-P. For this purpose, the following items were sent to the experts: (a) a video in which an individual is performing the MADAAMI-P sequence of movements; (b) the initial version of the scoring score sheet; (c) the User Manual; and (d) a MADAAMI-P evaluation questionnaire.

After Reading the User's Manual, the experts watched the video, analyzed the subject's execution, and completed the score sheet. Also, after this process, the experts should answer the evaluation questionnaire, which contained the following questions: (1) As to the clarity and ease of understanding and use of the proposed score sheet to evaluate the video, in general, you consider it : very adequate, adequate or not adequate? and (2) Would you have general suggestions, comments or modifications to make about the language used in the score sheet or other features related to the MADAAMI-P instrument? The first question was assessed using the Content Validity Index (CVI), which measures the proportion of the experts that concord regarding an instrument as a whole (Alexandre & Coluci, 2011). The CVI was calculated as the ratio between positive answers (very adequate and adequate) and the totality of the answers (6 answers), varying from zero (worst case) to one (best index).

The entire content validation process was carried out individually and independently by the experts. Based on the suggestions and comments, the initial version of the score sheet was modified, and then sent to the experts for approval or further suggestions. After this process, the final version of the MADAAMI-P evaluation score sheet (Figure 3) was obtained, and the appropriate adjustments were made in the User Manual.

(c) Intra- and inter-rater reproducibility

In this third stage of the study, the same researcher made a digital video recording of each subject executing the sequence of three movements that constitute the MADAAMI-P. Initially palpation and marking of the following anatomical points in each individual were performed bilaterally: ASIS, navicular bone and second metatarsal-phalangeal joint. After marking the points, the individual was positioned at the evaluation site, that is, behind the plumb line, with the second toe of each foot and the heels aligned on the parallel lines. The choice of positioning of the feet in one of the three lines marked on the floor was at the discretion of each individual. However, this choice should be symmetrical for both feet.

Once positioned, the subjects were oriented as to the sequence of movements to be performed: knee semi-flexion, knee flexion at 90° and knee semi-flexion in unipodal support. Before the recording began, individuals were asked to perform the sequence of movements once or twice for familiarization purposes.

After the data collection, the videos were analyzed using the final version of the score sheet. For the inter-rater reproducibility, three distinct raters (R1, R2, R3) analyzed the videos only once, independently and without conferring. Undergraduate students, two physiotherapists and one physical education teacher, all in the last year of their courses, with little experience in postural evaluation, where invited to participate in this stage. The raters read the User's Manual, having previously received training in the analytical process from an experienced physiotherapist (2 meetings with 3 hours each). The reliability of the three raters' answers determined the inter-rater reproducibility (Bartlett & Frost, 2008). For intra-rater reproducibility, only one of the raters (R1) repeated the analysis of each video with an interval of seven days. The reliability of the responses of the first and second day of R1's analyses determined intra-rater reproducibility (Bartlett & Frost, 2008).

Statistical analysis

The MAADAMI-P scores for each subject were tabulated to enable subsequent statistical analysis. To check reproducibility, the following scores were then extracted from the evaluation score sheet: (1) summation of right lower limb scores, (2) summation of left lower limb scores, (3) summation of knee semiflexion movement in bipodal support, (4) summation of bending movement at 90 ° of knees, (5) summation of knee semi-flexion movement in unipodal support for right lower limb, (6) summation of knee semi-flexion movement in unipodal support for the left lower limb, (7) the sum of the knee semiflexion movement in total unipodal support, (8) MADAAMI-P total score, and (9) individual scores for each criterion in each assessed movement phase, for right lower limbs and left separately.

The data were analyzed in IBM SPSS version 22 (IBM Inc., Chigaco, USA), adopting the level of significance of 0.05 in all the inferential analyzes. Initially the data were confirmed by the Kolmoronov-Smirnov test. Cohen's Kappa coefficient was used for analysis by categories, performed in the reproducibility verification phase, considering the following classification: ≤0 = poor; between 0.01-0.20 = weak; between 0.21-0.40 = reasonable; between 0.41-0.60 = moderate; between 0.61-0.80 = significant; and between 0,81-1,0 = almost perfect (Landis & Koch, 1977). For the analysis of MADAAMI-P final scores, the Intraclass Correlation Coefficient (ICC) was used. $ICC_{1,2}$ was used for intra-rater reproducibility, and $ICC_{1,3}$ was used for the inter-rater reproducibility (Krebs, 1986; Weir, 2005). The ICC was classified as excellent (ICC> 0.75), satisfactory (ICC 0.4 - 0.75), and poor (ICC < 0.40) (Fleiss, Levin, & Paik, 2004).

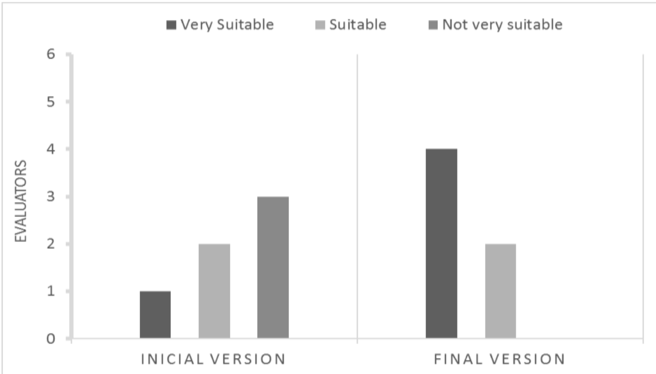


Figure 2. Results of content validation.

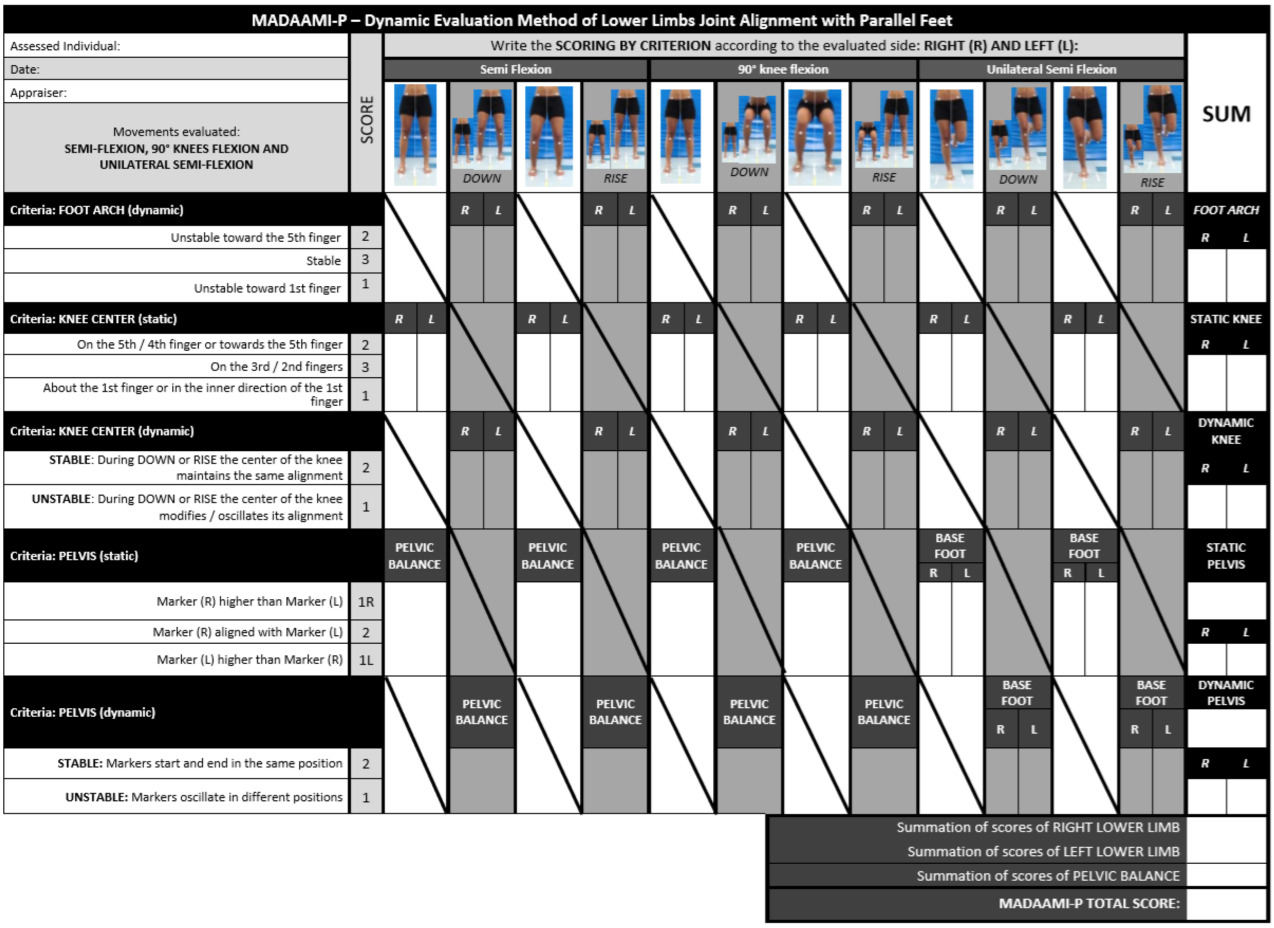
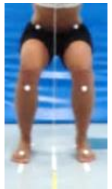
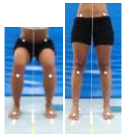
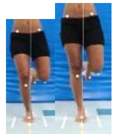


Figure 3. Score sheet developed for MADAAMI-P.

Table 1

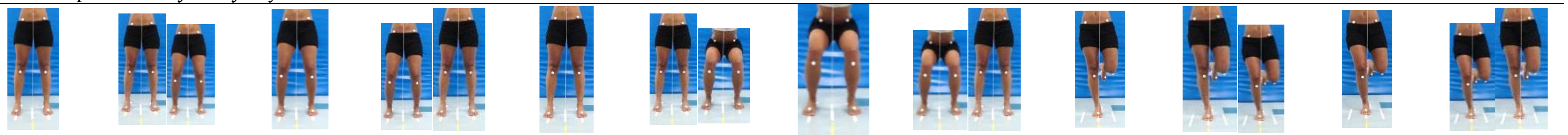
Results of the INTRAEVALUATOR reproducibility analysis for the criteria evaluated in MADAAMI-P.

Critério																									
		EKM1		DSF		SF		ASF		EKM2		DF90		F90		AF90		EKM3		DUSF		USF		USSA	
				R	L			R	L			R	L			R	L			R	L			R	L
Foot Arch	Kappa	-		0,79	1,00	-		0,79	1,00	-		0,85	1,00	-		0,79	1,00	-		0,71	0,62	-		0,74	0,62
	SE(K)	-		0,43	0,49	-		0,43	0,49	-		0,36	0,49	-		0,43	0,49	-		0,22	0,23	-		0,25	0,23
	K/SE(K)	-		1,8	2,1	-		1,8	2,1	-		2,3	2,1	-		1,8	2,1	-		3,1	2,6			2,9	2,6
Knee		R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	Kappa	0,84	0,65	0,69	0,63	0,70	0,72	0,64	0,85	0,74	0,75	0,81	0,81	0,81	0,76	0,85	0,64	0,62	0,69	0,89	0,81	0,77	0,66	0,64	0,80
	SE(K)	0,11	0,11	0,29	0,32	0,10	0,10	0,40	0,36	0,11	0,10	0,27	0,27	0,10	0,12	0,36	0,40	0,11	0,11	0,19	0,16	0,11	0,10	0,14	0,14
	K/SE(K)	7,8	5,9	2,4	2,0	7,0	7,0	1,6	2,3	6,7	7,2	3,0	3,0	7,7	6,5	2,3	1,6	5,6	6,5	4,8	5,1	6,9	6,3	4,5	5,5
Pelvis		PB		PB		PB		PB		PB		PB		PB		PB		R	L	R	L	R	L	R	L
	Kappa	0,82		1,00		0,71		0,90		0,81		0,78		0,83		0,74		0,87	0,83	1,00	0,62	0,88	0,81	1,00	0,65
	SE(K)	0,10		0,16		0,10		0,16		0,10		0,15		0,10		0,15		0,15	0,15	0,25	0,21	0,14	0,13	0,25	0,23
	K/SE(K)	8,0		6,0		7,0		5,4		8,0		5,2		8,0		5,0		5,6	5,4	4,0	3,0	6,2	6,0	4,0	2,9

Legend: EKM1 - Extended knee of movement 1; DSF – Descent Semi Flexion; SF - Semi Flexion; ASF -Ascent of Semi Flexion; EKM2 - Extended knee of movement 2; DF90 -Descent knee flexion at 90 °; F90 - 90 ° knee flexion; AF90 - Ascent of the knee by 90 °; EKM3 – Extended knee of movement 3; DUSF – Descent Unilateral Semi Flexion; USF – Unilateral Semi Flexion; USSA - Unilateral Semi Flexion Ascent. R -Right; L - Left; PB- Pelvic Balance; SE(K) – Standart Error of Kappa.

Table 2

Results of the INTEREVALUATOR reproducibility analysis for the criteria evaluated in MADAAMI-P.



Criterion		EKM1		DSF		SF		ASF		EKM2		DF90		F90		AF90		EKM3		DUSF		USF		USSA	
				R	L			R	L			R	L			R	L			R	L			R	L
Foot Arch	Kappa	-		0,65	0,85	-		0,70	0,85	-		0,68	0,85	-		0,65	0,73	-		0,17	0,26	-		0,23	0,35
	SE(K)	-		0,31	0,36	-		0,31	0,36	-		0,29	0,36	-		0,31	0,33	-		0,14	0,14	-		0,18	0,16
	K/SE(K)	-		2,1	2,4	-		2,3	2,4	-		2,3	2,4	-		2,1	2,2	-		1,2	1,8	-		1,3	2,2
Knee		R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
	Kappa	0,48	0,34	0,03	-0,04	0,27	0,33	0,06	-0,04	0,36	0,27	0,23	0,06	0,28	0,43	0,04	-0,04	0,12	0,19	0,25	0,20	0,16	0,25	0,15	0,09
	SE(K)	0,06	0,05	0,11	0,12	0,06	0,07	0,12	0,13	0,06	0,06	0,10	0,11	0,08	0,09	0,10	0,12	0,06	0,06	0,08	0,08	0,09	0,08	0,08	0,08
	K/SE(K)	7,9	5,8	0,3	-0,3	4,2	4,4	0,5	-0,4	5,9	4,4	2,3	0,5	3,5	4,7	0,4	-0,4	1,9	3,1	3,0	2,4	1,8	3,0	1,8	1,1
Pelvis		PB		PB		PB		PB		PB		PB		PB		PB		R	L	R	L	R	L	R	L
	Kappa	0,70		0,41		0,61		0,38		0,64		0,32		0,63		0,26		0,65	0,46	0,23	0,28	0,70	0,56	0,25	0,18
	SE(K)	0,06		0,10		0,06		0,11		0,06		0,08		0,06		0,08		0,10	0,12	0,15	0,14	0,11	0,08	0,14	0,15
	K/SE(K)	11,5		3,9		10,3		3,5		10,6		4,0		10,5		3,2		6,1	3,7	1,5	2,0	6,4	6,6	1,7	1,2

Legend: EKM1 - Extended knee of movement 1; DSF – Descent Semi Flexion; SF - Semi Flexion; ASF -Ascent of Semi Flexion; EKM2 - Extended knee of movement 2; DF90 -Descent knee flexion at 90 °; F90 - 90 ° knee flexion; AF90 - Ascent of the knee by 90 °; EKM3 – Extended knee of movement 3; DUSF – Descent Unilateral Semi Flexion; USF – Unilateral Semi Flexion; USSA - Unilateral Semi Flexion Ascent. R -Right; L - Left; PB- Pelvic Balance; SE(K) – Standart Error of Kappa.

Table 3

Results of the INTRAEVALUATOR analysis for the score of MADAAMI-P.

	Arch of the foot		Static Knee		Dynamic Knee		Static Pelvis		Dynamic Pelvis	
	ICC (ICAS%)	p	ICC (ICAS%)	p	ICC (ICAS%)	P	ICC (ICAS%)	P	ICC (ICAS%)	p
Pelvic Balance	-	-	-	-	-	-	0,783 (0,622–0,876)	0,000*	0,955 (0,921–0,974)	0,000*
Right Lower Member	0,631 (0,357–0,788)	0,000*	0,895 (0,817-0,940)	0,000*	0,826 (0,697–0,900)	0,000*	0,959 (0,929–0,976)	0,000*	1,000 (1,000–1,000)	-
Left Lower Member	0,692 (0,464–0,823)	0,000*	0,760 (0,582–0,862)	0,000*	0,847 (0,734 – 0,912)	0,000*	0,938 (0,861–0,964)	0,000*	0,803 (0,656–0,887)	0,000*
Semiflexion	0,652 (0,397–0,800)	0,000*	0,887 (0,803–0,935)	0,000*	0,756 (0,575 – 0,860)	0,000*	0,762 (0,585–0,863)	0000*	0,987 (0,978–0,993)	0,000*
Flexion 90°	0,797 (0,646–0,883)	0,000*	0,800 (0,651–0,885)	0,000*	0,816 (0,679 – 0,894)	0,000*	0,807 (0,663–0,889)	0,000*	0,895 (0,816–0,939)	0,000*
Semiplexion in Unipodal Right Support	0,784 (0,624–0,876)	0,000*	0,763 (0,586–0,864)	0,000*	0,892 (0,812 – 0,938)	0,000*	0,959 (0,929–0,976)	0,000*	1,000 (1,000–1,000)	-
Semiplexion in Unipodal Left Support	0,692 (0,464–0,823)	0,000*	0,763 (0,587–0,864)	0,000*	0,903 (0,832 – 0,944)	0,000*	0,938 (0,891–0,964)	0,000*	0,803 (0,656–0,887)	0,000*
Semiplexion in Unipodal Support	0,690 (0,460–0,822)	0,000*	0,814 (0,676–0,893)	0,000*	0,895 (0,817 – 0,940)	0,000*	0,951 (0,914–0,972)	0,000*	0,941 (0,898–0,966)	0,000*
Total Score	0,582 (0,272–0,760)	0,001*	0,845 (0,730–0,911)	0,000*	0,823 (0,691 – 0,898)	0,000*	0,833 (0,708–0,904)	0,000*	0,947 (0,907–0,969)	0,000*

Table 4

Results of the INTEREVALUATOR analysis for the sums of MADAAMI-P.

	Arch of the foot		Static Knee		Dynamic Knee		Static Pelvis		Dynamic Pelvis	
	ICC (ICAS%)	p	ICC (ICAS%)	P	ICC (ICAS%)	P	ICC (ICAS%)	p	ICC (ICAS%)	p
Pelvic Balance	-	-	-	-	-	-	0,699 (0,522–0,817)	0,000*	0,668 (0,474–0,798)	0,000*
Right Lower Member	0,321 (-0,075–0,588)	0,049	0,591 (0,352 – 0,752)	0,000*	0,483 (0,181–0,686)	0,002*	0,699 (0,523–0,817)	0,000*	0,468 (0,157–0,677)	0,004*
Left Lower Member	0,143 (-0,359–0,479)	0,253	0,608 (0,379 – 0,762)	0,000*	0,063 (-0,485–0,431)	0,384	0,555 (0,295–0,730)	0,000*	0,469 (0,159–0,678)	0,003*
Semiflexion	0,263 (-0,167–0,553)	0,096	0,565 (0,310 – 0,736)	0,000*	0,008 (-0,571–0,398)	0,476	0.674 (0,483–0,802)	0,000*	0,652 (0,448–0,789)	0,000*
Flexion 90°	0,126 (-0,385–0,469)	0,280	0,424 (0,087 – 0,650)	0,009*	0,271 (-0,155–0,558)	0,089	0,680 (0,493–0,806)	0,000*	0,600 (0,367–0,757)	0,000*
Semiplexion in Unipodal Right Support	0,057 (-0,494–0,428)	0,394	0,451 (0,130 – 0,667)	0,005*	0,478 (0,172–0,683)	0,003*	0,699 (0,523–0,817)	0,000*	0,470 (0,160–0,678)	0,003*
Semiplexion in Unipodal Left Support	0,214 (-0,245–0,523)	0,151	0,635 (0,422 – 0,778)	0,000*	0,369 (0,000–0,617)	0,025*	0,555 (0,295–0,730)	0,000*	0,469 (0,159–0,678)	0,003*
Semiplexion in Unipodal Support	0,095 (-0,434–0,451)	0,330	0,578 (0,332 – 0,744)	0,000*	0,496 (0,201–0,694)	0,002*	0,634 (0,420–0,778)	0,000*	0,507 (0,219–0,701)	0,001*
Total Score	0,234 (-0,213–0,535)	0,127	0,620 (0,399 – 0,770)	0,000*	0,347 (-0,035–0,603)	0,035*	0,591 (0,351–0,751)	0,000*	0,647 (0,441–0,789)	0,000*

RESULTS

The content validation results show that 50% of the invited experts considered the score sheet to be inappropriate in the first evaluation, 33.3% suitable, and 16.6% very suitable, which correspond a CVI equal to 0.5. After its reconstruction based on suggestions and comments, 66.6% of the experts considered it very suitable, 33.3% suitable, and none of the experts considered it to be unsuitable (Figure 2), with a CVI of 1.0. Based on this result, the final version of the MADAAMI-P score sheet was obtained (Figure 3).

Intra-evaluative analysis, for each criterion alone, showed, in general, that MADAAMI-P presents reproducibility, with Kappa values varying from 0.62 to 1.00, indicating a reproducibility of important to near-perfect. In this analysis, both arch criteria of the foot and pelvis were the ones that obtained the highest reproducibility indexes (Table 1).

The inter-analyzer analysis, referring to the criterion of arch of the foot in bipodal support, indicated reproducibility from important to almost perfect in (Kappa ranging from 0.65 to 0.85). In the knee criterion, in both unipolar and bipodal support, Kappa values indicated a reproducibility from poor to reasonable (-0.04 to 0.48). And, for the pelvic criterion the values of K indicated reproducibility from weak to important (0.18 to 0.70) (Table 2).

The MADAAMI-P intra-evaluative analysis, given by the sum of the points obtained in each phase of the movement, for each criterion, showed ICCs ranging from 0.582 to 1.00, indicating a reproducibility from satisfactory to excellent. The pelvic criterion, both static and dynamic, was the one with the highest values of CHF (Table 3).

The inter-analyzer analysis of MADAAMI-P, given the sum of the points obtained in each phase of the movement, for each criterion, showed ICCs varying from 0.008 to 0.669, and some of the partial scores did not present significant correlations. The pelvis criterion, both static and dynamic, was the one that presented the highest values of CHF, indicating a satisfactory reproducibility of this criterion, whereas the criterion of arch of the foot was not reproducible, having ICC values ranging from 0.057 to 0.321 (Table 4).

DISCUSSION

Regarding the evaluation of lower limb articular alignment, different methods are described for static evaluation. We can cite subjective visual assessment (J. Lee & Park, 2016), radiological examinations (Cho, Ko, & Lee, 2015; Gao et al., 2016; Moyer, Wirth, Duryea, & Eckstein, 2016; Zampogna et al., 2015) or angular measurements by goniometry (Karukunchit, Puntumetakul, Swangnetr, & Boucaut, 2015; Lee, Choi, & Chang, 2015). For the dynamic assessment of the lower limb articular alignment, some studies have been conducting using 3D camera systems in combination with retro-reflexive markers (Khamis et al., 2015; Pohjola et al., 2014; Shippen, 2011). It is a laboratory-based evaluation system requiring adequate space and specific costly equipment, as well as trained personnel, hich makes access difficult for the general population. Considering this, the intention of the present study was to offer an alternative evaluation tool to such systems.

The MADAAMI-P instrument is valid, with respect to content, and reproducible, for use by the same rater. In this case, we highlight its usefulness as an evaluation tool in the therapeutic environment, as long as the follow-up of an individual being treated, for example, is performed by the same professional. Regarding inter-rater reproducibility, the findings of the present study corroborate with the results of the study by Gontijo, Candotti, Amaral, Santos, and Loss (2018). The data highlight the subjective nature of the evaluation, revealing the sensitivity of the tool in relation to the clinical view and the experience of each rater, hampering good reliability between raters.

Regarding the criteria evaluated by the instrument, the arch of the foot and the pelvis showed better inter-rater reproducibility results than the knee. This can be explained by the anatomical differences of the structures involved in each criterion, since the knee is a more unstable joint, especially when flexed (Kapandji & Articular, 1990), a position performed during

MADAAMI-P evaluation movements. Moreover, the knee is difficult to evaluate compared to other joints because it is located at the extremity of two noncongruous structures, the femur and the tibia, allowing it to move more freely, guided by muscles and ligaments (Magee, 2005). Thus, identifying the center of the knee, in movement, without technological resources, such as movement tracking systems, is not an easy task. While developing the MADAAMI-P, we conducted tests using markers on the patella and anterior tibial tuberosity, which proved unsuitable for representing the center of the knee, inducing the raters to error. Hence, we opted for a more subjective analysis (i.e. without markers on the knee), which could explain the poor results for inter-rater reproducibility.

Among the results found, in the inter-rater analysis, we can emphasize the divergences related to evaluation in bi or unipodal support. This finding may be related to increased instability in unipodal support (Assaiante, 1998; Oliveira, Santos, Andrade, & Avila, 2008), which causes a greater oscillation in the joints, hampering the inter-rater reproducibility. As with the evaluation of the knee, the subjectivity of the analysis allied to the clinical experience of each rater appears to be a factor limiting inter-rater reproducibility.

Likewise, the pelvis tends to be more stable than the knee or ankle, due to anatomical/kinesiological characteristics which ensure less oscillation. This makes the analysis simpler, with less variation between the markers on ASIS left and right, leading to better inter-rater reproducibility results in this criterion (Germain, 1992; Kapandji & Articular, 1990; Magee, 2005).

The study presents clinical relevance, mainly in the area of physiotherapy. When considering the achievement of good intra-evaluative results in a therapeutic environment, it is possible to extrapolate the use of the tool, since the possible follow-up of an individual is done by the same professional. In addition, the record of the execution of the movements as well as the scoring score are very attractive visuals in clinical practice, serving as feedback and encouragement to the individual in treatment/training.

Limitations of the study

We observed in the present study as limitations the dependence on the subjective clinical view of the examiner in the evaluation, leading to heterogeneous evaluations from the different raters. Another limitation refers to the analysis of a 3D-movement based on a view from a single plane. Furthermore, the absence of the concurrent validation procedure, from the comparison of MADAAMI-P results with the cinemetry can also be considered a limitation of the study.

CONCLUSION

Dynamic Evaluation Method of Lower Limb Joint Alignment with Parallel Feet (MADAAMI-P) is valid in terms of content (score sheet), and presents intra-rater reproducibility, being safely indicated for use by the same rater. However, the inter-assay reproducibility of the instrument is limited to some parameters, suggesting caution when used by more than one examiner. In addition, it is emphasized once again the clinical importance of the instrument, especially in physiotherapy, serving as an effective quantitative method to obtain the record of movement execution, which together with the scoring score, are attractive visual resources in clinical practice, serving as feedback and encouragement to the individual in treatment / training.

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