REVIEW

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Relation between posture and spine and pelvis flexibility: a systematic review

Relação entre postura e flexibilidade da coluna e pelve: revisão sistemática

Relación entre la postura y la flexibilidad de la columna y la pelvis: revisión sistemática

Liliane Martini Araújo, Arthur Antoniolli, Emanuelle Francine Detogni Schmit, Cláudia Tarragô Candotti*

Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil

Abstract

Introduction: Changes in body structure positioning are associated with muscle flexibility and joint mobility, but evidence of this relationship is still incipient. Objective: To identify evidences of correlation between parameters regarding static body posture in orthostasis and spine and pelvis flexibility and/or mobility. **Methods:** Systematic review guided by the PRISMA Statement and the recommendations of the Cochrane Collaboration (PROSPERO: CRD42015026298). A search of the BIREME, EMBASE, PubMed and Science Direct databases was carried out, considering the beginning of the databases until January 16, 2017, with the terms and Boolean operators "posture" AND "spine" OR "pelvis" AND "range of motion, articular" OR "movement". To be included in the review, studies should present observational or clinical

*LMA: MS, e-mail: liliaraujofisio@gmail.com
AA: MS, e-mail: tuianto@hotmail.com
EFDS: Doctoral student, e-mail: manu_schmit@hotmail.com
CTC: PhD, e-mail: claudia.candotti@ufrgs.br

trial methodological designs, have sampled healthy individuals, present correlation or association test results between static posture and mobility/flexibility in the sagittal plane, and be published in Spanish, English or Portuguese. The methodological quality was evaluated by the Downs & Black scale and evidence by the GRADE system. **Results:** A total of 5,326 studies were obtained, seven of which were included after the establishment of the eligibility criteria. All studies presented high methodological quality, although a considerable heterogeneity regarding the choice of instruments and evaluation protocols was noted, reflecting contradictory results. Therefore, the present systematic review presents a moderate strength of evidence. **Conclusion:** No definitive evidence is yet available concerning the possible relationship between body posture and spine and pelvis flexibility and mobility.

Keywords*:* Posture. Pliability. Spine. Pelvis. Review.

Resumo

Introdução: *Alterações no posicionamento das estruturas corporais podem estar associadas à flexibilidade muscular e à mobilidade articular, mas essas evidências ainda são incipientes.* ***Objetivo:*** *Identificar se existem evidências de correlação entre parâmetros da postura corporal estática em ortostase e a flexibilidade e/ou a mobilidade da coluna vertebral e da pelve.* ***Métodos:*** *Revisão sistemática direcionada pelo PRISMA Statement e nas recomendações da Colaboração Cochrane (PROSPERO: CRD42015026298). Foram conduzidas buscas nas bases de dados BIREME, EMBASE, PubMed e Science Direct, considerando o início das bases até o dia 16 de janeiro de 2017, com os termos e operadores booleanos "posture" AND "spine" OR "pelvis" AND "range of motion, articular" OR "movement". Para serem incluídos, os estudos deveriam apresentar desenho metodológico observacional ou ensaio clínico, amostra de indivíduos saudáveis, resultado de teste de correlação ou associação entre postura estática e mobilidade/flexibilidade no plano sagital, e redação em idioma espanhol, inglês ou português. A qualidade metodológica foi avaliada pela escala de Downs & Black e a força de evidência pelo sistema GRADE.* ***Resultados:*** *Foram encontrados 5.326 estudos, sendo sete incluídos após crivo dos critérios de elegibilidade, os quais apresentaram elevada qualidade metodológica. Contudo, é considerável a heterogeneidade no que diz respeito a escolha de instrumentos e protocolos avaliativos. Diante disso, a presente revisão sistemática apresenta moderada força de evidência.* ***Conclusão:*** *Ainda não existem evidências definitivas sobre as possíveis relações entre a postura corporal e a flexibilidade e mobilidade da coluna vertebral e da pelve.*

Palavras-chave: *Postura. Maleabilidade. Coluna Vertebral. Pelve. Revisão.*

Resumen

Introducción*: Los cambios en el posicionamiento de las estructuras corporales pueden estar asociados a la flexibilidad muscular y la movilidad articular, pero estas evidencias todavía son incipientes.* ***Objetivo:*** *Identificar si existen evidencias de correlación entre parámetros de la postura corporal estática en ortostasa y la flexibilidad y/o la movilidad de la columna vertebral y de la pelvis.* ***Métodos:*** *Revisión sistemática dirigida por el PRISMA Statement y en las recomendaciones de la Colaboración Cochrane (PROSPERO: CRD42015026298). Se realizaron búsquedas en las bases de datos BIREME, EMBASE, PubMed y Science Direct, considerando el inicio de las bases hasta el 16 de enero de 2017, con los términos y operadores booleanos "posture" AND "spine" OR "pelvis" AND "range de movimiento, articular" OR "movement". Para ser estudios incluidos deben presentar diseño de observación y estudio de muestras de ensayos clínicos de individuos sanos, resultado de la prueba de correlación o asociación entre la postura estática y la movilidad/flexibilidad en el plano sagital, y la escritura en lengua española, inglés o portugués. La calidad metodológica fue evaluada por la escala de Downs & Black y la fuerza de evidencia por el sistema GRADE.* ***Resultados:*** *Se encontraron 5326 estudios, siendo siete* *incluidos tras el tamizaje de los criterios de elegibilidad, los cuales presentaron elevada calidad metodológica. Sin embargo, es considerable la heterogeneidad en lo que se refiere a la elección de instrumentos y protocolos de evaluación. Por lo tanto, la presente revisión sistemática presenta una moderada fuerza de evidencia.* ***Conclusión:*** *Aún no existen evidencias definitivas sobre las posibles relaciones entre la postura corporal y la flexibilidad y movilidad de la columna vertebral y de la pelvis.*

Palabras clave*: Postura. Docilidad. Columna Vertebral. Pelvis. Revisión.*

Introduction

Body posture, in a biomechanical concept, can be defined as the alignment or orientation of body segments in order to maintain a vertical position [1]. Complementing this definition, Braccialli & Vilarta [2] indicate that the American Academy of Orthopedics focuses on issues related to the maintenance of the equilibrium between active (musculotendinous) and passive (osteoarticular and ligamentous) subsystems [3, 4]. Moreover, posture comprises a dynamic relation, in which different tissues adapt in response to stimuli, internal or external, expressing a certain body position [5, 6].

Thus, it seems reasonable to accept that changes in the positioning of body structures, or body shape in space, are associated with muscle flexibility and joint mobility [7, 8] i.e., the way the individual moves prints "marks" on his/her body that may be either useful or harmful [9, 10]. When muscles are in equilibrium, they optimize body functioning, leaving useful marks that contribute to a harmonious state, allowing bodily freedom, or, in other words, flexibility and mobility. On the other hand, a muscular imbalance generated by excess activity of a certain muscle or a set of muscles ends up leaving harmful marks, which may prevent one or sets of muscles from exercising their main role, movement [11].

In addition, the intimate connection between the vertebral column and pelvic girdle structures, which integrate the center of the body, a stability region, plays a role in load absorption and dissipation [3]. Thus, in addition to strength and rigidity to maintain intervertebral anatomical relationships and protect neural elements, this connection must also, in contrast, be flexible, in order to allow freedom of movement [12].

Regarding the active subsystem, reductions in extensibility and/or muscle activity may affect the compensatory and exacerbated activity of the passive subsystem [3]. For example, psoas muscle activity may result in pelvic anteversion, with a consequent increase in lumbar lordosis [13], whereas, during predominant ischiatibial activity, the postural reflex probably results in pelvic retroversion [14]. Such modifications, over time, can lead to subsystem adaptations, with consequent adoption of a new posture, reflecting in movement alterations.

It should also be pointed out, conceptually, that flexibility is considered a physical fitness component related to the extensibility of soft tissues [15], which, in association with joint mobility, is considered one of the factors responsible for individual postural differences [2, 9, 16, 17]. Furthermore, flexibility and mobility are directly related, and can be considered as either complementary or synonymous [18].

Nevertheless, although some consensus exists regarding the close relationship between body posture and flexibility and mobility [2, 12, 16], evidence is still incipient, especially with regard to the positioning that the body will adopt, which encompasses the osteomioarticular system. In this sense, the following research question arose: does a relationship between parameters concerning static body posture in orthostasis and flexibility and/or mobility of the spine and pelvis exist? To answer this question, the present study carried out a systematic review to identify the correlation evidence between parameters concerning static body posture in orthostasis and flexibility and/or mobility of the spine and pelvis.

Methods

Study type

The present study comprised a systematic literature review [19] directed by the PRISMA Statement [20] and based on the recommendations of the Cochrane collaboration [21], registered in PROSPERO under code CRD42015026298[1].

Search strategies

In order to identify the studies of interest, the BIREME, EMBASE, PubMed and Science Direct databases were searched, independently and in duplicate, comprising the beginning of the databases until January 16, 2017. The following Boolean terms and operators "posture" AND "spine" OR "pelvis" AND "range of motion, articular" OR "movement" were used. An example of an applied search strategy is displayed in Figure 1.

Figure 1 - Search strategy applied at the PubMed database.

#1	"Posture" [mesh] OR "Postures" OR "Static posture"
#2	"Spine" [mesh] OR "Pelvis" [mesh] OR "Spinal Movements"
#3	"Range of Motion, Articular" [mesh] OR "Joint Range of Motion" OR "Joint Flexibility" OR "Flexibility, Joint" OR "Range of Motion" OR "Mobility" OR "Flexibility" OR "Movement" [mesh]
#4	#1 AND #2 AND #3

Eligibility criteria

The following eligibility criteria were established in order to select the studies encompassing this review: studies presenting methodological observational designs or clinical trials, presentation of the test results concerning correlation or association between static posture and mobility (or flexibility) variables in the sagittal plane, evidencing the degree and the meaning of the relation, samples comprising healthy individuals, published in Spanish, English or Portuguese.

Two independent evaluators carried out title and abstract assessments of the studies obtained by the database searches, in order to select those with the potential to meet the eligibility criteria. Subsequently, the selected studies were read in full, where the same reviewers, again independently, included studies that met the eligibility criteria in their entirety. Then, the bibliographic references of the included studies were consulted, to manually find new studies. As in the previous phases, the searches were carried out by the same evaluators, in an independent manner. A consensus among the evaluators was required at all stages, with no third evaluator.

Data extraction

The two evaluators independently applied a standardized form to extract relevant information from each included study, comprising authors, publication year, sample, software or protocol used for postural assessment and flexibility and/or body mobility, analyzed segments and body planes, and statistical results. This information was then compiled into a final worksheet. Whenever required, the reviewers consulted the original article again, to obtain agreements regarding the extracted information.

Study assessments

The scale proposed by Downs & Black [22] was used to assess the methodological quality of the included studies. This evaluation instrument consists in a 27-item checklist, in which applied scale items are assigned a point. When items are not applied, the score is zero. This instrument was applied due to its reproducibility and internal consistency [22], as well as flexibility, capable of assessing both observational studies and clinical trials. When the study being assessed is a clinical trial, all 27 items of the instrument are considered. In contrast, only 12 items are considered for observational studies, pertinent to this type of methodological design (Table 1).

When the assessed study included at least 70% of the items used for methodological quality assessment, it was considered as presenting high methodological quality [23], while studies with the inclusion of less than 70% were classified as presenting low methodological quality. As in previous phases, this step was performed independently by two evaluators, and divergences were resolved by consensus.

Evidence strength

The GRADE system (Grading of Recommendations Assessment, Development and Evaluation) was applied to classify the quality of the evidence and the strength of the recommendation provided by this systematic review, which takes into account the following criteria: systematic review, methodological limitations of the included studies, inconsistency (homogeneity of the studies), whether the studies present direct evidence, the accuracy of the results presented in included studies and if the systematic review presents any publication bias, not including all published studies on the research problem [24].

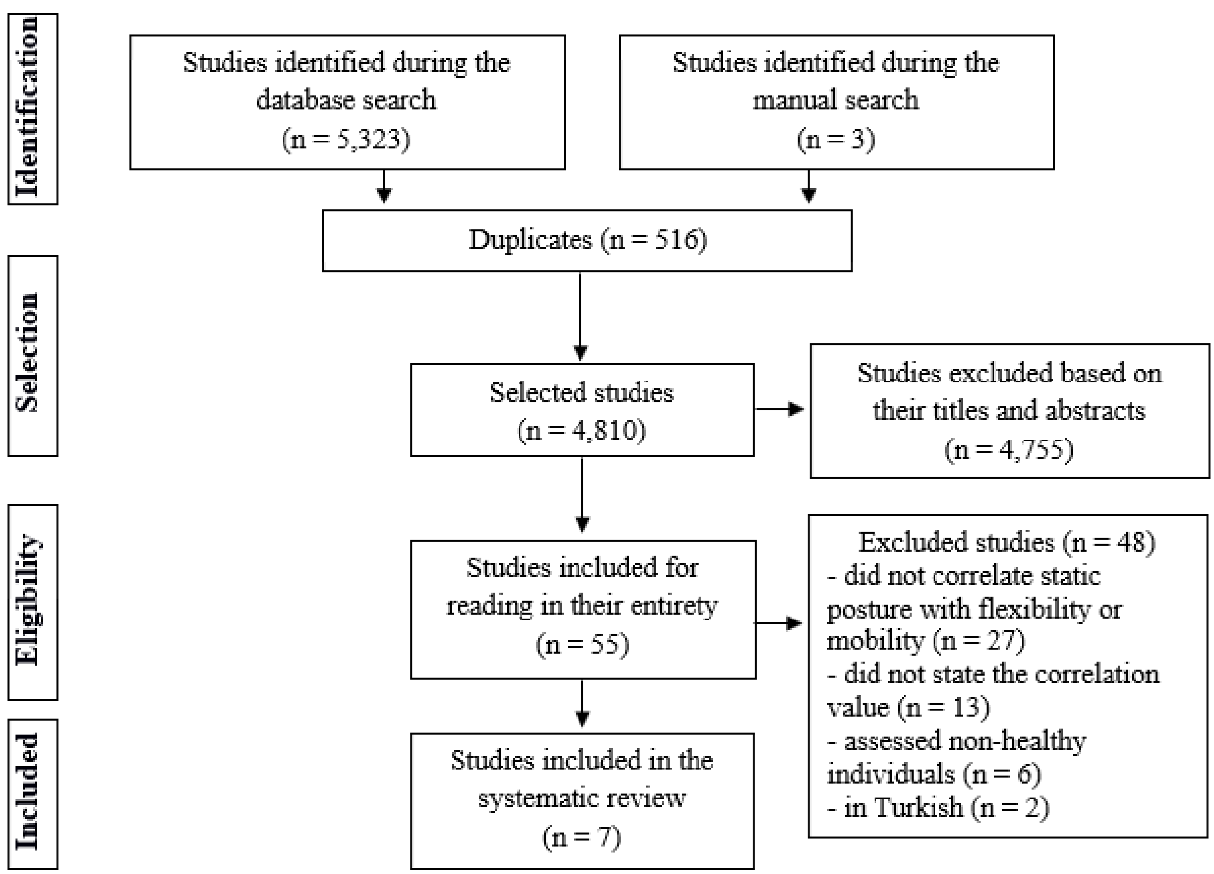
[1] (http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42015026298).

Based on the established criteria, a classification regarding level of evidence among the four levels presented by the system is attained, comprising: high quality — it is very unlikely that additional research will change the results presented by the systematic review; moderate quality — further research is likely to have a major impact and may change the results presented by the systematic review; low quality — other research is more likely to have a significant impact and alter the results presented by the systematic review; and very low quality — any estimation of results presented by the systematic review is very uncertain, generating the need for further studies.

Results

A total of 5,323 studies were obtained from the four searched databases, and another three articles were included in the manual search. Of this total, 516 were duplicates, leaving 4810 studies to be analyzed by title and abstract assessments. At this stage, 4755 studies did not meet the eligibility criteria, with 55 studies remaining to be read in their entirety. Of these, only seven covered all eligibility criteria and were included in the review. Figure 2 displays the flowchart of the study inclusion stages in this systematic review according to PRISMA guidelines [20].

Figure 2 - Flowchart of the study inclusion stages in the systematic review.



The main methodological characteristics of the included studies are presented in Tables 1 and 2, alongside methodological quality assessment information.

Table 1 – Characteristics of included studies

(to be continued)

First author (year)	Sample	Postural Assessment		Flexibility and/or Mobility Assessment		Result
		Instrument	Assessed segment	Instrument	Assessed segment and movement	
Bridger (1989) [25]	25 women (22±3.2 years old)	Inclinometer	Thoracic (T1/T2 – T12/L1) Lumbar (T12/L1 – L5/S1)	Inclinometer	Lumbar — flexion and extension Hips — flexion and extension	Thoracic x Hip flexion: r=-0.42. p<0.05 Thoracic x Hip extension: r=0.36. p<0.05 Thoracic x Hip extension with flexed knee: r=0.13. p>0.05 Lumbar x Hip flexion: r=-0.49. p<0.05 Lumbar x Hip extension: r=-0.44. p<0.05 Lumbar x Hip extension with flexed knee: r=-0.34. p>0.05 Thoracic x Lumbar flexion: r=0.27. p>0.05 Thoracic x Lumbar extension: r=0.21. p>0.05 Lumbar x Lumbar flexion: r=-0.17. p>0.05 Lumbar x Lumbar extension: r=0.03. p>0.05
Edmondston (2011) [26]	40 individuals (20 men and 20 women; 24±3.6 years old)	Photogrammetry (ImageJ software)	Thoracic (T1 – T6 – T12)	Photogrammetry (ImageJ software)	Thoracic — extension standing, sitting, prone and on all fours	Thoracic x Standing thoracic extension: r=0.63. p<0.001 Thoracic x Sitting thoracic extension: r=0.70. p<0.001 Thoracic x Prone thoracic extension: r=0.78. p<0.001 Thoracic x Thoracic extension on all fours: r=0.79. p<0.001
Goldberg (2001) [27]	41 individuals (men and women; 70.5±5.3 years old)	Goniometer	Lumbar (L1 – S2)	Goniometer	Lumbar — flexion and extension	♀ Lumbar x Lumbar flexion: r=-0.69. p<0.001 ♂ Lumbar x Lumbar flexion: r=-0.82. p<0.001 ♂ Lumbar x Lumbar extension: r=0.72. p=0.008
Muyor (2013) [28]	75 men (34.79±9.46 years old)	Spinal Mouse	Thoracic (T1/2 e T11/12) Lumbar (T12/L1 to the Sacrum) Pelvis	Spinal Mouse and Inclinometer	Hamstring muscles	Thoracic x Hamstrings: r=-0.23. p=0.001 Lumbar x Hamstrings: r=0.21. p=0.05 Pelvis x Hamstrings: r=0.37. p=0.001

Table 1 – Characteristics of included studies

(conclusion)

First author (year)	Sample	Postural assessment		Flexibility and/or Mobility Assessment		Results
		Instrument	Assessed segment	Instrument	Assessed segment and movement	
Muyor (2013) [28]	75 men (34.79±9.46 years old)	Spinal Mouse	Thoracic (T1/2 e T11/12) Lumbar (T12/L1 to the Sacrum) Pelvis	Spinal Mouse and Inclinometer	Hamstring muscles	Thoracic x Hamstrings: r=-0.23. p=0.001 Lumbar x Hamstrings: r=0.21. p=0.05 Pelvis x Hamstrings: r=0.37. p=0.001
Ohlen (1988) [29]	64 girls (11.9±2.7 years old)	Brunner Kyphometer and Inclinometer	Lumbar (T11/12 – S1/2)	Inclinometer	Lumbar — flexion, extension and total	Lumbar x Lumbar flexion: r=0.33 Lumbar x Lumbar extension: r=-0.69 Lumbar x total lumbar AM: r=-0.38
Toppenberg (1986) [30]	103 girls (12.5 to 16 years old)	Inclinometer	Thoracic Lumbar Pelvis	Myrin Goniometer	Abdominal, Paravertebrae, Iliopsoas, gluteal, Rectus femoris and Hamstring muscles	Thoracic x Paravertebrae: r=0.016. p>0.05 Thoracic x Abdominal: r=-0.245. p<0.05 Thoracic x Iliopsoas: r=-0.051. p>0.05 Thoracic x gluteal muscles: r=-0.106. p>0.05 Thoracic x Rectus femoris: r=0.027. p>0.05 Thoracic x Isquiostibiais: r=-0.193. p>0.05 Lumbar x Paravertebrae: r=-0.240. p<0.05 Lumbar x Abdominal: r=0.209. p<0.05 Lumbar x Iliopsoas: r=-0.196. p>0.05 Lumbar x gluteal muscles: r=-0.110. p>0.05 Lumbar x Rectus femoris: r=-0.078. p>0.05 Lumbar x Hamstrings: r=-0.213. p<0.05 Pelvis x gluteal muscles: r=-0.014. p>0.05 Pelvis x Rectus femoris: r=0.131. p>0.05 Pelvis x Hamstrings: r=-0.026. p>0.05
van Adrichem (1973) [31]	248 individuals (girls and boys; 6 to 18 years old)	Visual assessment	Lumbar	Schöber test	Lumbar — flexion	Lumbar x Lumbar flexion 6 to 12 years old ♀: r=0.008. p>0.05 ♂: r=0.245. p<0.05 13 to 18 years old ♀: r=0.193. p>0.05 ♂: r=0.232. p>0.05

Table 2 - Scoring and score of each study in the methodological quality evaluation by the Downs & Black scale

First author (year)	01	02	03	06	07	09	10	11	12	16	18	20	No. of √	quality %	High quality
Bridger (1989) [25]	√	√	√	√	√	√	√	X	X	√	√	√	10	83	Yes
Edmondston (2011) [26]	√	√	√	√	√	√	√	√	X	√	√	√	11	92	Yes
Goldberg (2001) [27]	√	√	√	√	√	√	√	√	X	√	√	√	11	92	Yes
Muyor (2013) [28]	√	√	√	√	√	√	√	√	X	√	√	√	11	92	Yes
Ohlen (1988) [29]	√	√	√	√	√	√	√	√	√	√	√	√	12	100	Yes
Toppenberg (1986) [30]	√	√	√	X	√	√	√	√	√	√	√	X	10	83	Yes
van Adrichem (1973) [31]	√	√	√	√	√	√	√	√	√	√	√	√	12	100	Yes

Downs & Black Scale Criteria: 1) Are the purpose and the hypothesis clearly stated? 2) Are the main results to be measured clearly described in the introduction or in the material and methods section? 3) Are the main characteristics of the included individuals clearly described? 6) Are the main findings clearly described? 7) Does the study estimate the data variability in the main findings? 9) Have the characteristics of the lost participants been described? 10) Are the true probability values for the main results presented? 11) Are the subjects invited to participate in the study representative of the population from which they were recruited? 12) Are the subjects prepared to participate in a study representative of the population from which they were recruited? 16) Is it clear if any of the results were based on "data dredging"? 18) Were the statistical tests adequate? 20) Have the measures of the main outcomes been accurate? Answers to the criteria: √: Yes; X: No.

None of the assessed studies scored <70% in the methodological quality assessment, indicating high quality for all included studies (Table 2). Thus, considering the GRADE criteria, the present systematic review presents moderate strength of evidence by summarizing information regarding the correlation between static posture variables and flexibility and the mobility with respect to the vertebral column and pelvis. However, due to the heterogeneity of the studies resulting from methodological divergences, no statistical analysis through a meta-analysis was possible.

Discussion

Evidence regarding correlations between static body posture parameters (thoracic spine, lumbar spine and pelvis) and spine and pelvis flexibility and mobility are still incipient. Although the studies included in the present review present high methodological quality, a particularly unfavorable methodological heterogeneity is noted, especially regarding the choice of the applied instruments and evaluation protocols.

The inclinometer was the most applied instrument [25, 28, 29, 30], followed by the goniometer [27, 30], photogrammetry [26] and the spinal mouse [28], all used for both postural and flexibility and mobility assessments, but presenting protocol variations. Other instruments were also applied for posture assessments, such as visual inspection [31] and kyphometer [29], and the Schöber test to assess flexibility and mobility [31].

Based on the above, the findings of this review demonstrate the lack of an evaluation standard for both postural issues and flexibility and mobility. Concerning spinal evaluations, X-ray examinations, considered by many as the gold standard [32-36], and photogrammetry, which has confirmed validity in relation to the gold standard [37, 38], were applied in the included studies, except for the study carried out by Edmondston et al. [26], which only applied photogrammetry. Regarding flexibility assessments, a lack of a standard gold instrument is still noted. Thus, the quality interpretations of assessment protocols must be based on repeatability and reproducibility psychometric indices. In this case, the choice of the inclinometer by the included studies was, in fact, adequate [25, 28-30].

As to the relationship between body posture and flexibility and mobility, there is evidence of a low to moderate correlation between the pelvic and thoracic and lumbar spine angles related to hamstring flexibility. However, these correlations are still incipient to provide definitive evidence, since they are controversial in the positive/direct and negative/inverse senses in most studies [25, 28, 30]. It is within this context, to return to anatomical questions in order to favor the understanding of such relationships. As hamstring muscles originate in the hip ischial tuberosity and posterior femur, they can directly interfere in pelvis positioning [39] when shortened or excessively elongated, and, consequently, in the ascending and descending segments, lumbar and knee, respectively [40-43].

Despite the use of different instruments for postural evaluation, the findings reported by Bridger, Wilkinson, Houweninge [25] and Muyor, Miñarro, Alacid [28] are the only ones that agree regarding a thoracic postural relationship with the hamstring musculature, based on moderate to low statistically significant inverse correlations, respectively. Thus, it is possible to speculate that the greater the angular value of the thoracic spine, the lesser the flexibility of the hamstrings, and, consequently, the lower the hip flexion. In addition, the same relation regarding lumbar spine posture is noted [25, 30].

Furthermore, based on the studies included in the present review [25, 30], results are conflicting regarding the correlation between the lumbar spine and iliopsoas flexibility, since only one of two included studies found a statistically significant inverse correlation [25]. The same study detected a direct and significant correlation between thoracic spine and iliopsoas flexibility [25]. In addition, other muscles involved in hip flexibility and mobility, such as the rectus femoris and gluteals, did not present statistically significant correlations with spine posture [25, 30].

The relationships between postural variables and the flexibility of the vertebral column itself were also discordant regarding the thoracic region and, thus inconclusive, regarding both trunk extension and flexion, lacking new studies [26, 30]. Toppenberg and Bullock [30] and Ohlen, Wredmark and Spangfort [29] agree on the existence of a significant and inverse correlation with trunk extension movement, even when applying different instruments, restricted to a sample of adolescent girls, suggesting that the greater the static lumbar angle, the lower the flexibility of the lumbar extension movement. This result is explained by Kapandji [44], who describes that the angle of lumbar lordosis in the orthostatic position is already in an extension position, thus diminishing the extension movement. In contrast, Goldberg and Chiarello [27] found a direct correlation between lumbar spine posture and lumbar extension. However, their study sample consisted of elderly individuals, who, due to senility, already display osteomioarticular system involvement. In addition, the applied lumbar extension measuring method may be questionable, since hip extension at the end of the movement was subtracted [27].

Also for the lumbar region, but regarding flexing, two studies reported an inverse correlation [27, 30] and two others, a direct correlation [29, 31]. In a biomechanical analysis of this relation, it would be coherent to say that the lumbar spine presents an inverse relation with lumbar flexion, since, in a standing position, however small the curve, it is the lumbar spine is extended [44]. Nevertheless, when performing the bending movement, if the lumbar is healthy and free, it will make a counter curve [42]. In view of the above, it is important to maintain a healthy relationship between the vertebral column and the pelvic girdle, both in terms of posture and flexibility [45].

It should be noted that, despite the rigorous methodological design adopted in the present study in an attempt to summarize and point out the best evidence concerning the relationship between static body posture and spine and pelvis flexibility and/or mobility, the fact that short and not so current studies were included, with the most recent publication published four years before the search was carried out, is a study limitation, revealing the lack of experimental studies regarding the investigated variables.

Conclusion

This review indicates lack of definitive evidence on the possible relationships between body posture and spine and pelvis flexibility and mobility. In sum, the results of this systematic review should be interpreted cautiously, considering the divergence of results between the included studies, which may be due to different methodological procedures, and the fact that the understanding of the relationship between posture and spine flexibility is of extreme importance for the clinical context. It is also important to restate the need to carry out new studies that apply gold standard instruments in their assessments and verify sample heterogeneity.

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