Title: Head and shoulder functional changes in flutists

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This work was presented at International Symposium of Performance Science, 2011, Toronto, Canada and at the National Association of Research and Posgraduate Courses in Music (Associação Nacional de Pesquisa e Pós-Graduação em Música), 2012, Universidade Federal de Paraíba, Brazil

ABSTRACT

Aims: This study aims at comparing head posture, symmetry of shoulder muscle strength and posture between developing flutists, professional flutists, and a matched control group of singers.

Method: Measurements of head and scapular posture and muscle strength were compared between flutists with 10 or less years of practice (developing flutists; n=9), flutists with more than 10 years of practice (professional flutists; n=9) and singers (n=9). Posture was measured using a goniometer and a tape measure; strength was assessed using an isokinetic dynamometer.

Results: Significant differences were found between groups concerning forward head posture only; developing flutists showed a higher forward head posture compared to the other two groups ($p < 0.05$). No significant differences were found for scapular posture neither for muscle strength.

Conclusions: Developing flutists showed significantly more forward head posture. This supports the need to revise existing music curricula targeting the inclusion of compulsory disciplines on music medicine.

Keywords: Flutists; Posture; Muscle Strength; Years of instrumental practice

INTRODUCTION

Intense mental and physical training is needed in order to achieve an excellent music performance [1]. To play a music instrument, considerable number of practicing hours are needed to develop neuromotor control of fine gestures [2]. These repetitive movements occur mostly in asymmetrical postures [3]. In addition, many instruments may require the use of a considerable amount of force, as they are heavy to sustain [4]. As a consequence, positive and negative body adaptations might occur. Among the positive changes, one might include increased brain interconnectivity (neuroplasticity), grey matter [5] and relative pitch ability [6] in musicians, as compared to non-musicians. Examples of negative changes are musculoskeletal problems and alterations in muscle strength and length. These might contribute to pain and mal adaptive performance anxiety [7, 8]. In extreme cases, musicians are compelled to stop performing [9].

Instrumentalists seem to be affected differently by musculoskeletal problems, depending on instrumental choice, studying habits, gender, age, personality, genetics, life-style and socio-economic conditions [7]. Guitar and flute players, for example, have been pinpointed as those presenting the most relevant asymmetrical postures during practice [10]. These players also present higher pain prevalence rate as compared to other instrumentalists [11]. An association between pain and static asymmetrical postures maintained for prolonged periods of time may exist [3]. This might be the case of flutists, as they need to hold the instrument horizontally at the level of the right shoulder, rotating the waist and misaligning the shoulders; the left shoulder is in adduction and flexion whereas the right is in abduction and extension [10]. The head is side-flexed to the right, rotated to the left and protruded [8]. These asymmetrical postures might decrease the mechanical advantage of the muscles, the consequence being an increase in their activity in order to maintain these postures [12]. The use of arms above the shoulder level, in particular for more than 2 hours a day, can also constitute a risk factor. For example, orchestral musicians who refer the highest pain prevalence are those who play with elevated shoulders, e.g., flutists, trombonists, violinists and viola players [13]. Thus, copying with an asymmetric body posture seems to constitute one of the strategies that a musician needs to develop [1]. Among this copying strategies, the implementation of music medicine classes on secondary and higher educational settings, focussing on anatomical, physiological, biomechanical and ergonomics has been commonly referred in the literature [14, 15]. Continuing education of instrumental teachers in music medicine has also been pointed out as a preventive strategy [16]. Instrumental teachers are the first ones to be notified by the student in case of musculoskeletal or other medical problems [15]. This study aims at investigating whether changes exist in head posture, scapular posture and in shoulder muscle strength symmetry in developing flutists and professionals.

METHOD

Participants

Flutists and singers, recruited among students and lecturers at the Department of Communication and Arts, University of Aveiro (Portugal), volunteered to participate. Flutists were divided into 2 groups according to their years of practice: less than 10 years (developing flutists; n=9) and more than 10 years (professionals; n = 9). Ten years of instrumental practice served as a division between groups of flutists, because age has been referred as an influent risk factor [17] and 10 years were considered to be required to achieve a proficient level in music [18]. Singers were chosen as the control

group as singing normally does not require asymmetric body postures neither elevated arm position (n = 9). They were matched for level of expertise and age.

Ethical approval to carry out this study was given by the Ethics Committee of the Hospital Infante D. Pedro, in Aveiro. All participants received information sheets containing details of the study procedures. After reading the implications of becoming a participant, all voluntarily signed a written consent form.

Dataset collection

Dataset were collected, including: (i) self-reported pain, assessed by means of a questionnaire; (ii) head and scapular posture, measured at the Department of Communication and Arts at the University of Aveiro by the author AGS, a Physical Therapist with more than 10 years of experience; and (iii) torque of internal and external shoulder muscle rotators. The latter measurements took place at the Hospital Infante D. Pedro, in Aveiro, and were collected by a medical doctor in the final year of his physical medicine and rehabilitation specialization. Dataset included 3 measurement repetitions for each of the assessed variables, with the exception of the self-report pain questionnaire which was filled in only once.

Procedure

For pain assessment, participants were asked to fill in the Portuguese version of the Nordic Musculoskeletal Questionnaire (NMQ) [19], which collects information on the location, and intensity of pain, for the last 7 days, 3 and 6 months prior to the questionnaire. For the purpose of this investigation, only data referring to shoulder and neck was collected. Pain was assessed as it has been commonly associated with postural changes [20].

Head posture was characterized by measuring three anatomic angles. The first angle was formed by the line connecting C7 to the tragus of the ear and the horizontal. This allows the assessment of head posture relative to the trunk. Decreasing values for this angle indicate a more forward head posture. The second angle was formed by the line connecting the tragus of the ear to the canthus of the eye and the horizontal. This allows the characterisation of head extension; increasing values are indicative of a more extended head. And finally, the third angle formed by the line connecting the inferior margins of both ears and the horizontal, provides information on side flexion. These angles were particularly chosen because they have been considered by previous studies as enabling reliable comparisons (ICC≥.71) [20]. All measurements (repeated three times) were performed using a universal goniometer, made of two mobile arms, which were fixed at a central point named the axis. A bubble level was used to maintain one of the goniometer's arm aligned with the horizontal line of reference (see Figure 1).

Figure 1. Measure of forward head posture by means of a goniometer and a bubble level.

To assess the posture of the right and left scapula, a similar procedure to that described by Sobush et al. (1996) was followed. The participant remained in a relaxed position and four distances were measured: (1) the perpendicular distance between the superior angle of the scapula and the vertebral spine; (2) the perpendicular distance between the medial aspect of the root of the scapula and the vertebral spine (see Figure 2, left panel); (3) the perpendicular distance between the inferior angle of the scapula and the vertebral spine; and (4) the height difference between both scapulas (see Figure 2, right panel). Before measuring these distances, anatomical points in the scapula were identified and marked, using a vertical line as a reference to identify the spine.

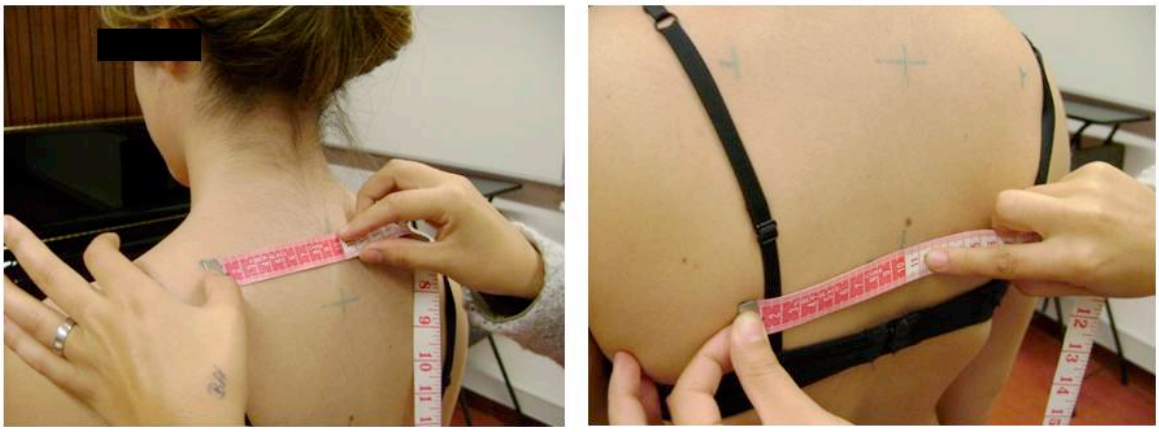

Figure 2. Measure of the perpendicular distance between the superior angle of the scapula and the spinous processes of the dorsal column (left panel) and the perpendicular distance between the inferior angle of the scapula and the spinous processes of the dorsal column (right panel). Anatomical points were first identified and marked, and distances measured by means of a tape.

Muscle strength of the internal and external rotators of both left and right shoulders was assessed using an isokinetic Dynamoter (Biodex Medical System). Isokinetic resists applied forces and controls the speed of movement at a predetermined rate while measuring the maximum strength of participants. These were performed in concentric isotonic contractions and at 3 different velocities: 30º/s, 60º/s and 90º/s. Participants were seated in the isokinetic chair, with the arm at approximately 30º of abduction and the elbow flexed at 90º (see Figure 3). Total muscle work and average power were determined: the first indicates muscle ability to produce force throughout movement

range; the second corresponds to the total muscle work divided by time. These measures were chosen as static and asymmetric postures to sustain the flute might lead to differences between the right and left shoulder torque measurements.

Figure 3. Measure of the strength internal and external shoulder rotators by means of an Isocinetic Dynamoter (Biodex Medical System).

Statistical analysis

Data were analyzed using the *Statistical Package for the Social Sciences (*IBM, version 17). For head posture, the mean value between the three measurements was calculated and used for analyzes. For the scapular posture and muscle strength the mean difference between the right and left measurements was used. These differences were calculated in order to remove the effect of body size and characterize asymmetry between left and right scapular postures. As data were skewed, the median and interquartile ranges were calculated. Kruskal-Wallis was used to assess whether differences between groups existed concerning the several analyzed parameters. If significant differences were found, a Mann-Whitney (Wilcoxon) statistical test was applied to investigate which group was responsible for these differences.

RESULTS

A high number of participants in all groups reported the neck as the most painful region during the 3 and 6 months prior to this study: 78% for developing flutists and singers (7 out of 9 participants), and 89% for group professional flutists (8 out of 9 participants). For the last 7 days prior to the questionnaire, singers were the ones reporting less neck pain (34%, 3 out of 9). Generally, neck pain intensity in this region was similar for both groups of flutists, and considerably less intense for the singer's group (assessed only for the last 7 days prior to the study).

Shoulder pain felt 6 months prior to this study was also reported in all groups: 34% for developing flutists and singers (3 out of 9 participants); and 55% for professional flutists (5 out of 9 participants). For the last 3 months, shoulder pain was less reported by for developing flutists and singers (22%, 2 out of 9); more professional flutists reported shoulder pain (45% to 55%, or 4 to 5 participants out of 9). For the last 7 days prior to the questionnaire, no shoulder pain was reported by singers. As concerned to shoulder

pain intensity in the last seven days, it was reported only by professional flutists, being slightly higher on the right as compared to the left shoulder (Table 1).

Table 1. Distribution of perceived pain for all groups, referring to the last 6months, 3 months and 7 days prior to this investigation. The median and interquartile range of perceived pain intensity for the 7 days prior to this study are displayed in the last two columns (Med = median; IQR = interquartile range).

Pain location	Groups	Pain Presence			Pain Intensity	
		Last 6 months	Last 3 months	Last 7 days	Last 7 days	
		n (%)	n (%)	n (%)	Med	IQR
Neck	Developing flutists	7 (78%)	7 (78%)	7 (78%)	2.4	1
	Professional flutists	8 (89%)	8 (89%)	8 (89%)	2.2	2.8
	Singers	7 (78%)	7 (78%)	3 (34%)	0	2.3
Right shoulder	Developing flutists	3 (34%)	2 (22%)	2 (22%)	0	3
	Professional flutists	5 (55%)	4 (45%)	4 (45%)	2.2	2.2
	Singers	3 (34%)	2 (22%)	0 (0%)	0	0
Left shoulder	Developing flutists	3 (34%)	2 (22%)	3 (34%)	0	1.1
	Professional flutists	5 (55%)	5 (55%)	5 (55%)	0.8	3
	Singers	3 (34%)	2 (22%)	0 (0%)	0	0

Concerning head posture, a significant difference was found between groups: developing flutists showed the lowest values of the angle between C7, the tragus of the ear and the horizontal [χ^2 (2) = 7,03; p = 0,03] (see Table 2). Thus, this group presented a significant more forward head posture as compared with the other two (see Figure 4).

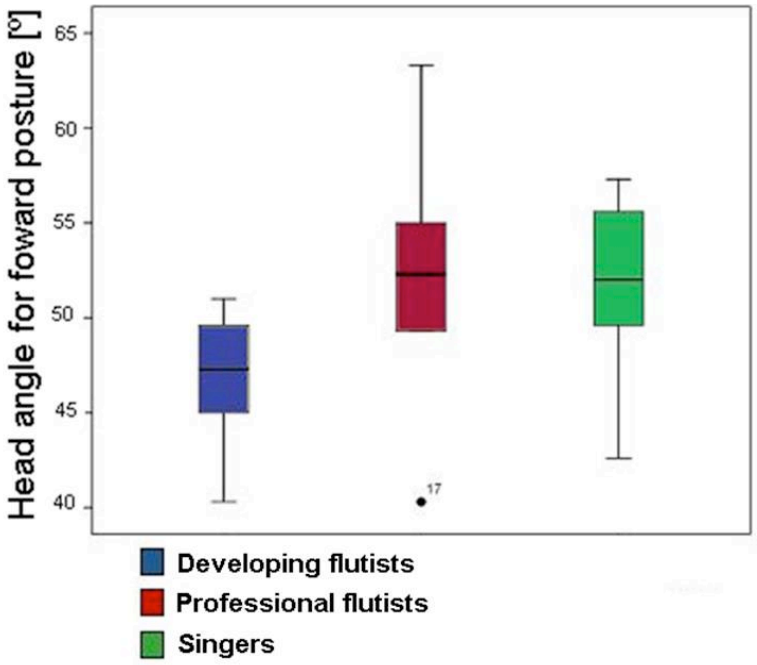

Figure 4. Forward head posture comparisons between groups. Flutists with less than 10 years of practice (blue) present lower values of head posture angle as compared to flutists with more than 10 years of practice (red) and singers (green). Number 17 in group 2 is an outlier.

Significant differences between groups for head extension and side flexion postures could not be found (see Table 2).

Table 2. Head posture comparisons (forward, extension and flexion) between participant groups (n=number of participants in each, Med = median; IQR = interquartile range). Significant differences between groups were found only for the forward head posture: group 1 presented the highest forward head position.

Head posture angle	Developing flutists (n = 9)		Professional flutists (n = 9)		Singers (n = 9)		Mann-Whitney (Wilcoxon) test
	Med	IQR	Med	IQR	Med	IQR	
Forward head posture	47.3	4.6	52.3	5.7	52	6	χ^2 (2) = 7.03; p = 0.03 *
Head extension	21.3	5.7	26.6	4.7	19.3	3.3	χ^2 (2) = 3.21; p = 0.20
Head side flexion	2.6	6	1.6	2.4	1.3	2.3	χ^2 (2) = 1.76; p = 0.42

* Mann-Whitney (Wilcoxon) test significance p<0.05

Table 3 displays the differences between measurements of right and left scapular posture. Significant differences between groups could not be found.

Table 3. Difference between right and left scapular posture for the three groups of participants. Median (Med) and interquartile range (IQR) were calculated for the 3 repetitions of these measures (n=total number of participants in each group). No significant differences were found.

Differences between right and left scapulas	Developing flutists (n = 9)		Professional flutists (n = 9)		Singers (n = 9)		Kruskal-Wallis
	Med	IQR	Med	IQR	Med	IQR	
Right and left superior scapular angle difference	1.6	1.2	1.3	1.8	0.7	0.6	χ^2 (2) = 4.26; p = 0.12
Right and left root scapular difference	1.1	0.6	0.3	1.7	0.9	0.9	χ^2 (2) = 0.54; p = 0.76
Right and left inferior scapular angle difference	0.6	0.6	0.6	0.7	0.4	0.7	χ^2 (2) = 0.995; p = 0.61
Right and left superior scapular angle height difference	0.8	0.6	0.6	0.5	1	0.8	χ^2 (2) = 0.737; p = 0.69

Kruskal-Wallistest significance p<0.05

The same applies to muscle strength measures of concentric isotonic contractions at 3 different velocities (see Table 4).

Table 4. Muscle strength concentric contraction difference between left and right shoulders, for 3 different velocities, between the three groups of participants. Median (Med) and interquartile range (IQR) were calculated for the 3 repetitions of these measures (n=total number of participants in each group). No significant differences were found.

Muscle strength concentric contraction difference between left and right shoulders			Developing flutists (n = 9)		Professional flutists (n = 9)		Singers (n = 9)		Kruskal-Wallis
			Med	IQR	Med	IQR	Med	IQR	
30°/s velocity	**External rotation**	**Total muscle work difference**	1.4	0.9	3.4	3.5	3.1	4.8	χ^2 (2) = 3.91; p = 0.14
		Mean power difference	0.6	1.3	0.6	0.7	0.9	0.9	χ^2 (2) = 1.32; p = 0.52
	Internal rotation	**Total muscle work difference**	5.0	3.5	0.6	3.4	0.7	3.5	χ^2 (2) = 0.35; p = 0.84
		Mean power difference	1.0	0.6	1.5	1.4	1.5	1.5	χ^2 (2) = 2.46; p = 0.29
60°/s velocity	**External rotation**	**Total muscle work difference**	2.6	1.3	1.4	1.2	1.1	2.4	χ^2 (2) = 1.85; p = 0.40
		Mean power difference	1.9	0.8	1.4	1.8	1.3	1.3	χ^2 (2) = 0.40; p = 0.82
	Internal rotation	**Total muscle work difference**	3.3	3.1	2.7	4.8	5.1	2.8	χ^2 (2) = 0.03; p = 0.60
		Mean power difference	1.7	1.2	1.7	1.4	1.2	1.4	χ^2 (2) = 1.80; p = 0.41
90°/s velocity	**External rotation**	**Total muscle work difference**	2.5	1.5	1.8	2.8	2.7	3.2	χ^2 (2) = 1.49; p = 0.48
		Mean power difference	1.7	1.4	1.5	1.6	3.5	5.1	χ^2 (2) = 2.84; p = 0.24
	Internal rotation	**Total muscle work difference**	4.7	5.0	3.0	3.1	3.6	7.8	χ^2 (2) = 2.96; p = 0.23
		Mean power difference	2.8	2.8	3.5	3.2	3.5	4.3	χ^2 (2) = 0.81; p = 0.67

* Kruskal-Wallis test significance p<0.05

DISCUSSION

This study rationale is based on previous investigations suggesting postural modifications and high prevalence of musculoskeletal disorders amongst musicians. Impairment of postural stabilization system has been associated with poor instrumental practice habits [21]. Deviations in posture may lead to decreased moment arm length, increased forces acting on anatomical structures [22] and decreased movement range [23]. These may facilitate the appearance of musculoskeletal disorders and pain [8]. A multitude of factors have been referred as potential causes to playing related musculoskeletal disorders. Amongst these, there are inefficient practicing habits [15], musculoskeletal system overuse, hypermobility [24], and asymmetric postures maintained for long periods [25]. Flutists have been pointed out as one of the most affected groups [13]. This study constitutes the first attempt to investigate whether changes in head and scapular posture and asymmetry of shoulder muscle strength exist in flutists.

As pain is one of the most important symptoms of musculoskeletal disorders, its presence and intensity was used to characterise the sample. Pain in the neck was reported by a high number of participants. This trend corroborates previous findings [13, 25].

Head posture was significantly different between groups only for forward head posture. This result is in agreement with previous observations [8]. One possible explanation for this negative physical adaptation could be the exposure to long hours of practice with the head anterior to the trunk and the shoulders lifted and protracted. This specific posture might be related with weakness of neck flexors and shortening of neck extensors [26]. The presence of a more forward head posture in the younger group of flutists also suggests that they are more prone to suffer from neck pain in the long term, as forward head posture has been associated with neck pain [20, 27].

One would expect that older flutists would also be affected [17]. Several possibilities may have accounted for this finding. One case scenario would be the presence of "*healthy worker effect*", i.e., subjects with pain and, consequently a more forward head posture (20), have changed occupation [28]. Secondly, professional flutists might have a better ability to control body posture than non-professionals; previous findings revealed that professional musicians possess greater metacognition as compared to non-professionals [29], which could be applied to posture. This is in agreement with sports science literature: skilled athletes possess greater ability to use optimised performance strategies when compared to less skilled ones [30]. Thirdly, it is possible that students, although aware of potential risks, they are not encouraged enough to adopt preventing behaviours of potential hazards. Despite attempts of implementing informative seminars on musician's health and wellbeing on musicians curricula [15], these seemed to be confined to few high education institutions [14].

An unexpected finding was that no significant differences were found for muscle strength, scapular posture, head extension and side-flexion between groups. However, this may be a false negative due to the small sample size and high within group variability. To overcome this type of error, future studies with adequately powered sample sizes should be carried out. Another limitation that can be pointed is that the control group of singers also presented pain. It would be necessary to include in the future other type of control groups for which neck pain is not present. This study also leads to the recommendation that posture should be measured in a dynamic way while

musicians are playing, for example applying motion capture technology. A final key idea is that there is a need to develop longitudinal studies if one's interest is to investigate the associations between time/years of playing and negative body modifications.

CONCLUSIONS

This study provides evidence of postural changes in developing flutists. The need for disciplines teaching coping strategies for the physical and mental demands of playing a music instrument within musician's curricula is enhanced.

ACKNOWLEDGEMENTS

The authors would like to thank all participants and the Hospital Infante D. Pedro, in Aveiro.

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