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Original Article

Assessing physiological and postural changes in clarinetists and oboists after a specific exercise program

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Abstract:
Problem statement: Musicians require good physical conditioning and posture to prevent injuries and muscular discomfort. In this study, we propose the implementation of a targeted exercise program for clarinetists and oboists to improve their overall physical fitness and posture. **Purpose**: This quasi-experimental intervention aims to enhance physical aptitude The first intervention was a pilot study with 18 exercise sessions for 19 clarinet and oboe students. The second intervention was an experimental study with 12 sessions for an additional 19 participants. The program was divided into three levels, with the complexity of tasks increasing every three weeks. The first level focused on adaptation to exercise with simple, low-intensity exercises. The second level emphasized skill development by increasing the number of sets and repetitions. The third level focused on functional development, incorporating more complex, global exercises. Statistical analysis was conducted using the t-test method. **Results**: Participants showed significant improvements in the strength of the trapezius and latissimus dorsi muscles (1 RM, $p = 0.001$). Posture analysis using the Langlade test revealed significant alignment improvements in the head–neck vertex ($p = 0.003$), retracted chin ($p = 0.025$), and alignment of the acromion with the greater trochanter and earlobe ($p = 0.008$). Additionally, while playing their instruments, there was significant alignment of the acromion with the earlobe and the greater trochanter ($p = 0.005$). Following various modifications, the second study confirmed significant improvements in the trapezius ($p = 0.003$) and latissimus dorsi ($p = 0.008$). **Conclusion:** The tests demonstrated favorable changes in body posture while playing the instrument. The proposed exercise program effectively enhances strength and promotes beneficial postural changes in standing position and while playing the instrument. This program may be an effective approach for injury prevention. Exercise programs should be tailored to the specific characteristics of the instrument and the musician.
Keywords: musicians, body posture, prevention, injury, physical activity

Introduction

Playing an instrument requires a range of physiological effort from light to hard (Baadjou et al., 2011; ACSM, 2021), depending on the muscle system's ability to maintain body posture either statically or dynamically, providing stability or generating movement (Derbez, 2014). Therefore, constant intermuscular coordination is necessary to maintain proper body posture with or without movement. To achieve good body posture while playing an instrument, an ergonomic anatomical posture in both standing and seated positions must be pursued (Klein et al., 2010; Ohlendorf et al., 2017). However, changes in the physiological curvature of the spine can result from factors such as muscle imbalance, incorrect body posture habits, obesity, sedentary behavior, and mood (Matei & Ginsborg, 2020; Solberg, 2008; Wilczyński et al., 2020).

These factors generate deficiencies in joint and spine mobility, eventually altering the physiological curvature (Blanco-Piñeiro et al., 2015; Eum et al., 2013), thus affecting the health and work activities of those affected (Rodrigues et al., 2014; Roos & Roy, 2018). Most musical instruments (e.g., flute, violin) are not ergonomic (Prada & Rey, 2014) because they were designed without considering human physiognomy, forcing musicians to adapt to the instrument's shape, size, or weight.

Consequently, these adaptations lead to mid-term musculoskeletal changes, such as scoliosis, hyperlordosis, and hyperkyphosis, related to conditions such as upper and/or lower crossed syndrome (Barczyk-Pawelec et al., 2011; Barczyk-Pawelec et al., 2012; Klein et al., 2010). Owing to the physical demands and inadequate adaptations to wind instruments, musicians often suffer from musculoskeletal problems such as tendinitis and back pain (Baadjou et al., 2016; Mirshahi et al., 2023), caused by unnecessary tension from

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incorrect posture and other issues affecting the nervous system, such as focal dystonia (Furuya & Oku, 2023; Schmidt et al., 2009). One way to prevent these issues is through exercise to tone weakened (hypotonic) muscles and improve the flexibility of rigid (hypertonic) muscles (Betsch et al., 2015; Rodríguez, 2008).

While prevention programs have proven effective in music centers, they are still not widely implemented in academic systems (Martín López & Farías Martínez, 2013; Nusseck & Spahn, 2020). Specific exercise programs for musicians are essential for maintaining their health (Chan et al., 2014) during and outside of instrumental playing (Nusseck & Spahn, 2020).

Various studies have shown improvements in body awareness (Lee et al., 2012), perceived physical capacity (De Greef et al., 2003), and a decrease in injuries and pain (Martín López & Farías Martínez, 2013; Usgu et al., 2022). Therefore, the objective of this research was to demonstrate the importance of physical exercise in improving the body posture of musicians, highlighting the need for individualized programs that consider each musician's specific requirements.

Methods

A quasi-experimental intervention was implemented to observe the effects of physical activity on body posture in musicians by modifying the causal factor of physical aptitude. This intervention consisted of a two-month program of specific exercises performed three days a week, individually and autonomously, through a multimedia website designed specifically for this purpose (https://musica.giepafs.net).

Based on results from a previous study (Gallego et al., 2018), the program prioritized the upper body and correct postural hygiene for instrumentalists. Participants agreed to participate by signing an informed consent form, and the study was approved by the ethics committee of the San Vicente Mártir Catholic University of Valencia (reference number: UCV2015-2016-37-v.3). Participants who frequently performed physical activity were excluded from the study.

Participants

The first phase (pilot) sample included 19 participants (7 men and 12 women), all clarinet and oboe students at the conservatory, with an average of 9.00 ± 3.33 years of experience.

The second phase (experimental) sample consisted of 19 musicians (9 men and 10 women), aged 16.89 ± 6.23 years, with an average of 7.95 ± 1.74 years of experience playing their instruments and the same level of musical studies as the first group.

Owing to the dropout rate during the second phase, participants were classified into four groups based on the number of sessions completed: Group 1: less than 5 sessions (N = 13); Group 2: 1–5 sessions (N = 6); Group 3: 6–9 sessions (N = 4); Group 4: 10–12 sessions (N = 3).

Intervention

The program was divided into three levels, with the complexity of tasks increasing every three weeks. The first level focused on adaptation to exercise with simple, low-intensity exercises. The second level emphasized skill development by increasing the number of sets and repetitions. The third level focused on functional development, incorporating more complex, global exercises. Each session was structured into three parts: warm-up, main activity, and cooldown.

Typically, each training session included a 5–6 min warm-up, 6–10 resistance exercises, and 5–6 flexibility exercises. The warm-up consisted of upper limb mobility exercises, short-duration isometric exercises, and low-intensity aerobic exercises. The main part of the session included mobility, aerobic, and strength exercises, progressing from targeting a few muscle groups to many, with particular emphasis on scapular and paravertebral exercises. Finally, the session concluded with flexibility exercises for the muscles worked or postural education exercises with the instrument.

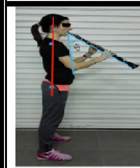
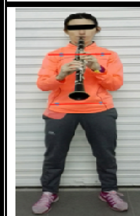
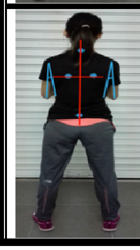
Procedure

The participants underwent pre- and post-tests, during which their VO2max was measured using the Rockport test (American College of Sports Medicine, 2021). The strength of the trapezius and latissimus dorsi muscles was evaluated using rowing exercises targeting the chin and one arm, respectively. The Brzycki prediction equation was then applied to estimate their 1 RM (LeSuer et al., 1997).

Additionally, three tests were selected to assess spine mobility (hip flexion, rotation, and trunk inclination) (Liebenson, 2007), including the Langlade test for standing posture (Langlade, 1987), which has been utilized by other contemporary authors (Daza, 2007).

An ad-hoc test called Langlade Instrument Clarinet (LINSTR-CL) was also employed to assess body posture specifically related to playing the clarinet, using the Langlade test as a reference point (Gallego, 2017) (Table I).

Table I. Langlade test adapted for clarinetists and oboists (Gallego, 2017).

Langlade test adapted for clarinetists and oboists		Yes	No	
Sagittal Plane	The vertex of the head and the neck remain horizontal while playing.			
	The chin is slightly rolled back while playing the instrument.			
	During practice, the acromion must be aligned with the earlobe and the center of the greater trochanter.			
	The arms form a 45°–60° angle with the instrument.			
	The body remains aligned during instrumental practice.			
Coronal Plane	The wrists are in a neutral position.			
	The shoulder, nipple, and iliac spine lines must be parallel.			
	The shoulders remain aligned during practice without unilateral trapezius contraction.			
	The shoulder blades must touch their vertebral border, and the inferior angle should be connected to the rib cage.			
	The elbows should be separated from the body by 30°–60°.			
	The C7 vertebra and the upper part of the intergluteal fold should align with the plumb line while playing.			
	The relief of the spinous processes along the spine should coincide with the plumb line while playing.			

In the second phase of the research, spine mobility tests were replaced (Liebenson, 2007) because all participants performed them adequately; thus, no significant additional information was gained. Instead, the shoulder flexibility test from the senior fitness test (Rikli & Jones, 2012) was incorporated.

Statistical analysis

All statistical analyses were performed using the SPSS v.20 (SPSS INC, Chicago, IL, USA) statistical package. The Shapiro–Wilk test was used to assess normality, along with descriptive statistics. For parametric variables such as the Rockport test and 1 RM, t-tests for related and independent samples were employed. The Wilcoxon T-test was utilized for non-parametric variables such as the Liebenson, Rikli, and Jones tests. A significance level of $p < 0.05$ was applied in all cases, with a confidence level of 95%.

Results

With regard to the results of the first phase (pilot study), concerning aerobic capacity, strength, and joint range of motion, the comparison of mean values (at the beginning and end of the test) of quantitative physiological variables (VO2max and Strength) using t-tests for related samples revealed no significant change in VO2max (Rockport and Polar Test) ($p > 0.05$). However, there was a significant improvement in trapezius strength ($p = 0.001$), increasing from 6.70 ± 2.46 to 8.53 ± 4.30 kg, and in latissimus dorsi strength, increasing from 7.17 ± 1.87 kg to 7.98 ± 1.80 kg, with a p-value = 0.001.

The Wilcoxon T-test for selected Liebenson tests assessing spine movement revealed variations only in the flexion of the left and right hips, with a significance of $p = 0.025$.

The results for body posture are detailed below. Analysis of the Langlade test during the first phase indicated significant improvement in initial and final body posture, particularly in maintaining horizontal alignment of the head and neck vertex (L1) ($p = 0.003$), slight retraction of the chin (L2) ($p = 0.025$), and alignment of the acromion vertex with the earlobe and greater trochanter (L3) ($p = 0.008$).

Similarly, analysis of the LINSTR-CL test showed significant improvements in LINSTR1 and LINSTR4 ($p = 0.014$ and $p = 0.005$, respectively), as presented in Table II, with positive changes in LINSTR2, LINSTR11, and LINSTR12 frequencies.

Table II. Wilcoxon related samples between the beginning and end of LINSTR-CL.

Variable	Evaluation	Yes%	No %	Significance
LINSTR1 The vertex of the head and neck remain horizontal while playing.	IE	68.40	31.60	**.014**
	FE	100	-	
LINSTR2 While playing the instrument, the chin is slightly rolled back	IE	94.70	5.30	.317
	FE	100	-	
LINSTR3 The shoulders are aligned during the practice. The trapezius is not unilaterally contracted	IE	84.20	15.80	.317
	FE	89.50	10.50	

LINSTR4 The acromion must be aligned with the earlobe and the center of the greater trochanter during the practice	IE	42.10	57.90	**,005**
	FE	84.20	15.80	
LINSTR5 The arms form an angle of 45º (clarinet)-60º(oboe) with the instrument	IE	52.60	47.40	.157
	FE	63.20	36.80	
LINSTR6 The body is aligned during the instrumental practice	IE	63.20	36.80	.157
	FE	73.70	26.30	
LINSTR7 The wrists are in a neutral position	IE	78.90	21.10	.157
	FE	89.50	10.50	
LINSTR8 The shoulder line, the nipple line, and the iliac spine line must be parallel	IE	89.50	10.50	1
	FE	89.50	10.50	
LINSTR9 The shoulder blades must touch their vertebral border and the inferior angle must be connected to the rib cage	IE	73.70	26.30	.317
	FE	78.90	21.10	
LINSTR10 The elbows must be separated from the body more than 30º	IE	89.50	10.50	.317
	FE	84.20	15.80	
LINSTR11 The C7 and the superior part of the intergluteal fold must be aligned with the plumb line while playing the instrument	IE	94.70	5.30	.317
	FE	100	-	
LINSTR12 The relief of the spinous processes throughout the spine must coincide with the plumb line while playing the instrument	IE	94.70	5.30	.317
	FE	100	-	

Note: N = 19; IE = Initial evaluation; FE = Final evaluation

Regarding the results of the second phase (experimental) tests on aerobic capacity, strength, and joint range of motion, the analysis of the parametric tests indicates that the general sample showed a decrease in VO2max from 57.46 ± 10.60 to 52.60 ± 10.47 ($p = 0.012$). There was a significant increase in strength evaluation for the trapezius from 8.23 ± 2.86 to 10.83 ± 5.77 ($p = 0.003$) and for the latissimus dorsi from 9.06 ± 3.55 to 9.86 ± 4.00 ($p = 0.008$), similar to the results of the previous phase.

According to the sample classification, the most significant results indicated that individuals who exercised for less than two and a half weeks experienced a decrease in aerobic capacity and only improved their strength in the trapezius. In contrast, the second group showed significant improvements only in the strength of the latissimus dorsi ($p = 0.006$). The other variables continued to improve in this group, but with a significance level of $p > 0.05$.

While the Ricki and Jones test for shoulder mobility did not yield significant results, frequency analysis revealed a 100% improvement in left shoulder joint range in flexion among participants in groups 3 and 4.

As observed in the results of the Langlade and LINSTR-CL body posture tests, the physiological modifications in strength achieved by the program in the global sample were not significant enough for each item assessing body posture to obtain a significant value. Nevertheless, the frequencies indicated maintenance or improvement in most cases (Table II).

Group 1 exhibited a significant increase in trapezius strength, with minimal changes observed in the alignment of the acromion with the earlobe and greater trochanter (L3) for 7.7% of participants (Table III).

The other groups obtained better results in each aspect assessed by the Langlade test, although with closer significance ($p = 0.05$ was $p = 0.083$ for items L3 and L4 in group 2) (Table III).

In the Mann–Whitney analysis by sex, the most notable finding was in item L4, where men exhibited greater improvement ($p = 0.030$) compared to women ($p = 0.478$) owing to the initial condition of the iliac crest and pubic symphysis in parallel position, which was worse in men.

Table III. Wilcoxon related samples between the beginning and end of Langlade (experimental group and groups 1–4).

		Experimental group			Group 1			Group 2			Group 3			Group 4		
	Ev.	**Yes%**	**No %**	**Si**	**Yes %**	**No %**	**Sig.**	**Yes %**	**No %**	**Sig.**	**Yes %**	**No %**	**Sig.**	**Yes %**	**No %**	**Sig.**
L3	IE	5.30	94.70	.3	7.7	92.3	.317	-	100	**,083**	-	100	.157	-	100	.157
	FE	15.80	84.20		-	100		50	50		50	50		66.7	33.3	
L4	IE	68.40	31.60	,0	76.9	23.1	1	*50	50	**,083**	50	50	.157	33.3	66.7	.157
	FE	84.20	15.80		76.9	23.1		100	-		100	-		100	-	
L5	IE	47.40	52.60	.3	69.2	30.8	1	-	100	.317	-	100	.317		100	.317
	FE	52.60	47.40		69.2	30.8		16.7	83.3		25	75		33.3	66.7	
L9	IE	73.70	26.30	.3	84.6	15.4	1	50	50	.317	25	75	.317	33.3	66.7	

	FE	78.90	21.10		84.6	15.4		66.7	33.3		50	50		66.7	33.3		
L10	IE	68.40	31.60	1	76.9	23.1	1	50	50	1	25	75	1	33.3	66.7	1
	FE	68.40	31.60		76.9	23.1		50	50		25	75		33.3	66.7	
L14	IE	94.70	5.30	.3	100	-	1	83.3	16.7	.317	75	25	.317	66.7	33.3	.317
	FE	100	-		100	-		100	-		100	-		100	-	
L15	IE	84.20	15.80	.3	84.6	15.4	1	83.3	16.7	.317	75	25	.317	66.7	33.3	.317
	FE	89.50	10.50		84.6	15.4		100	-		100	-		100	-	

Note: Ev. = Evaluation; IE = Initial Evaluation; FE = Final Evaluation; Sig. = Significance; Experimental group N = 9; Group 1 N = 13; Group 2 N = 6; Group 3 N = 4; Group 4 N = 3; L3 Acromion aligned with the earlobe and the greater trochanter; L4 Iliac crest parallel to the pubic symphysis; L5 Knees in the same plane of heel and forefoot; L9 Shoulders distended and aligned; L10 Shoulders and hips form two symmetric triangles with the center of the trunk; L14 Same plumb line in C7 and the intergluteal fold; L15 Spinous processes must be aligned. *Independent sample (sex), $p < 0.005$.

The experimental group exhibited significant changes in instrumental posture, as outlined in Table IV, particularly in the alignment of the earlobe with the greater trochanter and the abduction angle of the shoulders during practice, corresponding to LINSTR4 ($p = 0.014$) and LINSTR10 ($p = 0.046$), respectively.

Similar to the Langlade test by group, several items demonstrated improved values compared to the initial evaluation while playing the instrument. Notably, group 2 showed a significant enhancement ($p = 0.046$) in the alignment of the acromion with the earlobe and greater trochanter (LINSTR4) (Table IV).

Table IV. Wilcoxon related samples for the LINSTR-CL test (experimental group and groups 1–4)

		Experimental group						**Group 2**			**Group 3**			**Group 4**		
Variable	**Ev.**	**Yes %**	**No %**	**Sig.**	**Yes %**	**No %**	**Sig.**	**Yes %**	**No %**	**Sig.**	**Yes %**	**No %**	**Sig.**	**Yes %**	**No %**	**Sig.**
LINSTR1	IE	63.2	36.8	.564	69.2	30.8	1	50	50	.317	75	25	1	66.7	33.3	1
	FE	68.4	31.6		69.2	30.8		66.7	33.3		75	25		66.7	33.3	
LINSTR3	IE	36.8	63.2	1	30.8	69.2	1	50	50	1	25	75	.317	33.3	66.7	.317
	FE	36.8	63.2		30.8	69.2		50	50		50	50		66.7	33.3	
LINSTR4	IE	10.5	89.5	,014	15.4	84.6	.157	-	100	,046	-	100	.157	-	100	.157
	FE	42.1	57.9		30.8	69.2		66.7	33.3		50	50		66.7	33.3	
LINSTR5	IE	42.1	57.9	.102	53.8	46.2	.564	16.7	83.3	,083	-	100	.157	-	100	.317
	FE	63.2	36.8		61.5	38.5		66.7	33.3		50	50		33.3	66.7	
LINSTR6	IE	57.9	42.1	.317	53.8	46.2	1	66.7	33.3	.317	50	50	.317	33.3	66.7	.317
	FE	63.2	36.8		53.8	46.2		83.3	16.7		75	25		66.7	33.3	
LINSTR8	IE	47.4	52.6	.564	46.2	53.8	.317	50	50	1	25	75	.317	33.3	66.7	.317
	FE	52.6	47.4		53.8	46.2		50	50		50	50		66.7	33.3	
LINSTR9	IE	89.5	10.5	.317	92.3	7.7	1	83.3	16.7	.317	75	25	.317	66.7	33.3	.317
	FE	94.7	5.3		92.3	7.7		100	-		100	-		100	-	
LINSTR10	IE	73.7	26.3	,046	76.9	23.1	.157	66.7	33.3	.157	50	50	.157	66.7	33.3	.317
	FE	94.7	5.3		92.3	7.7		100	-		100	-		100	-	
LINSTR12	IE	78.9	21.1	.317	76.9	23.1	1	83.3	16.7	.317	75	25	.317	66.7	33.3	.317
	FE	84.2	15.8		76.9	23.1		100	-		100	-		100	-	

Note: Ev. = Evaluation; IE = Initial evaluation; FE = Final evaluation; Sig. = Significance; Experimental group N = 19; Group 1 N = 13; Group 2 N = 6; Group 3 N = 4; Group 4 N = 3; LINSTR1 The vertex of the head and the neck remain horizontal while playing; LINSTR3 The shoulders are aligned during practice. The trapezius is not unilaterally contracted; LINSTR4

The acromion must be aligned with the earlobe and the center of the greater trochanter during practice; LINSTR5 The arms form an angle of 45° (clarinet) – 60° (oboe) with the instrument; LINSTR6 The body is aligned during instrumental practice; LINSTR8 The shoulder, nipple, and iliac spine lines must be parallel; LINSTR9 The shoulder blades must be connected to the rib cage; LINSTR10 The elbows must be separated from the body by more than 30°; LINSTR12 The spinous processes must be aligned while playing the instrument.

Discussion

The second phase experienced a dropout rate of 68.42%, a figure similar to the 65.28% reported in a DVD-based exercise program involving 144 participants (Chan et al., 2014). A commonality between these programs was the autonomy granted to participants in session execution. As previously noted, the intensity of playing a musical instrument varies widely (American College of Sports Medicine, 2021; Baadjou et al., 2011). Therefore, designing tailored programs is crucial for maintaining physical fitness, enabling activity performance, and mitigating the high musculoskeletal injury rates (Silva et al., 2015; Andersen et al., 2017).

Overall, there were no improvements in VO2max. Significant conditioning effects were primarily observed in the initial eight weeks. However, the absence of changes underscores the need to reassess intensity and frequency planning, particularly beyond the second week and a half, considering factors such as potential demotivation towards proposed aerobic exercises or time constraints.

Significant changes were observed regarding strength, aligning with the prescribed exercises targeting the scapular region, as recommended by Betsch et al. (2015). These exercises improved musicians' posture and helped prevent or correct hyperkyphosis, common in clarinet and oboe players, adhering to progression principles. Improvements in shoulder joint range frequency during the second phase suggest the efficacy of including static flexibility exercises, as advised by ACSM (2021) and Barczyk-Pawelec et al. (2013), for hyperkyphosis prevention and enhanced joint mobility.

For the abovementioned reasons, the designed program produced effects similar to those in studies conducted by Lee et al. (2012) and Andersen et al. (2017) because the physical changes benefited health conditions, although they were not statistically significant. The most significant change in standing body posture across both phases was the alignment of the acromion with the earlobe and greater trochanter (L3). These changes also positively impacted LINSTR4 during instrument practice, indicating improved posture comparable to enhancements in physical condition (Chan et al., 2014), body awareness (Lee et al., 2012), and perceived physical ability (De Greef et al., 2003).

Conclusions

The tests revealed favorable changes in body posture while playing the instrument. The proposed exercise program facilitates positive strength development and encourages beneficial postural changes in standing position and during instrument execution, potentially serving as an effective injury prevention measure.
These findings suggest that tailored exercise programs for musicians enhance the physical abilities required for instrument performance and influence body posture. To optimize posture with the instrument, it is advisable to prioritize strength exercises, such as rowing, performed 2–3 times a week with gradually increasing intensity (3 sets, 10–15 repetitions), targeting muscles such as the rhomboids, serratus, and trapezius. Additionally, incorporating static stretches lasting 10–30 s three days a week can improve flexibility. Furthermore, integrating body postural education exercises while practicing with the instrument and a cooldown phase focusing on anterior muscle relaxation can further enhance posture.

In conclusion, exercise programs should be tailored to suit the specific characteristics of the instruments and individual musicians.

Conflicts of interest **-** none

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