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Original Article

Stabilometry profile in fixed seat rowers

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Abstract:

Balance in rowing boats is crucial for experienced and non-experienced rowers, allowing them to keep their blades off the water and keep the boat from rolling that requires rowers to contract muscles to even out the boat and to stabilize their bodies. The purpose of this study was to create reference stabilometric values in fixed seat rowing and compare them between male and female rowers in different sensorial conditions with eyes open and closed. Fifteen subjects voluntarily participated in this study, six male rowers and nine female rowers from University of Alicante fixed seat rowing team, all belonging to the senior category. A FreeMed baropodometric platform (Rome, Italy) was used for the stabilometric measurements: (TE) total excursion of the CoP, (CEA) area of the 95 % confidence ellipse, (MV) mean velocity, (MDx) mediolateral direction, (MDy) anteroposterior direction, (RMSx) amplitude in mediolateral direction and (RMSy) amplitude in anteroposterior direction. Results indicate that male rowers had greater ability to maintain balance than female rowers in bipodal stance with eyes open and closed. Female rowers demonstrated more ability to preserve sitting position than male rowers with eyes open and closed. However, there was no clear trend in relation to a greater balance between male and female in monopodal stance.
Key words: fixed seat rowing, stability, body balance, postural control.

Introduction

Application of technology in sports sciences has increased their knowledge and performance: motion analysis (Filippeschi & Ruffaldi, 2013; Jimenez-Olmedo, Pueo, & Penichet-Tomás, 2016; Basilio Pueo, 2016), contact platforms (Landolsi, Bouhlel, Zarrouk, Lacouture, & Tabka, 2014; B. Pueo, Lipinska, Jiménez-Olmedo, Zmijewski, & Hopkins, 2016), heart rate (Jimenez-Olmedo, Pueo, Penichet-Tomás, Chinchilla-Mira, & Perez-Turpin, 2017) or stabilometric platforms (Muehlbauer, Roth, Bopp, & Granacher, 2012; Romero-Franco et al., 2013) to analyse body balance.

Balance is the ability to maintain body's centre of gravity over its base of support describing the dynamics of body posture to prevent falling with minimal sway or maximal steadiness (Emery, 2003; Palmieri, Ingersoll, Stone, & Krause, 2002). Motor skills progress spontaneously but quality and quantity of motor activity with training can decide their final level (Famuła, Nowotny-Czupryna, Czupryna, & Nowotny, 2013) and in the case of postural control, it is a fundamental element in effective execution of movement in the different sports because if the sense of proprioception is not in good condition or fatigued, it could send wrong stimuli to the central nervous system (Romero-Franco, Martínez-López, Hita-Contreras, & Martínez-Amat, 2015; Romero-Franco, Martínez-López, Lomas-Vega, Hita-Contreras, & Martínez-Amat, 2012).

Reduced balance ability has been significantly correlated with an increased risk of injury in a number of sports. Postural stability deterioration and sports injuries have been studied due to relation with contractile inefficacy (Brito et al., 2012; Paillard, Costes-Salon, Lafont, & Dupui, 2002; Paillard et al., 2002). Knowledge about balance is useful to identify athletes with an increased risk of sport injury and to decide if an injured athlete can practise sport again without risk for reinjury (Hahn, Foldspang, Vestergaard, & Ingemann-Hansen, 1999; Han, Ricard, & Fellingham, 2009). Balance assessed with appropriate measurement tool is essential not only in rehabilitation and injury prevention but also to evaluate the effectiveness in proprioceptive balance training (Emery, 2003). The inclusion of proprioceptive training improves stability and reduces the risk of injuries (Michell, Ross, Blackburn, Hirth, & Guskiewicz, 2006).

Literature not only collects relationships between stability, injuries and proprioception training, but also uses the balance evaluation for the control and evaluation of training variables in sport because the improvement of postural control depend on the sport or the activity practiced (Asseman, Caron, & Crémieux, 2004; Beck et al., 2007). Athletes use certain sensorial information to control their posture depending on the requirement of their sport (Paillard & Noé, 2006). Some researchers examined physiology relationships between muscle fatigue and centre of pressure sway (Beck et al., 2007). Romero-Franco, Martinez-Lopez, Hita-Contreras, Lomas-Vega, & Martinez-Amat (2015) found important stabilometric deterioration right after a lactic training where effects disappeared 24 hours later. In Fox, Mihalik, Blackburn, Battaglini, & Guskiewicz (2008), the effect of fatigue

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remained present until 13 minutes after both aerobic and anaerobic exercise. Noda & Demura (2007) found significant differences in unit time sway and front-back sway immediately after exercise. Values returned to baseline levels 5 min after exercise. In addition to the exhausting exercise, gender, age or temperature could affect proprioception (Angyán, Téczely, & Angyán, 2007). This study also concludes that increase in BMI, back muscle strength and endurance capacity is associated with better postural stability.

Other authors have studied different relationships between postural stability and their sports. In football Brito et al. (2012) suggested that postural stability assessed with eyes open is reduced after a competitive soccer match and Paillard et al. (2002) described national-level soccer players had better stability than those in the regional level, who trained less frequently and less intensely. In rock climbing, slow and controlled static movements, could be a value in the treatment of functional ankle instability (Schweizer, 2005). Even Era, Konttinen, Mehto, Saarela, & Lyytinen (1996) analyzed rifle shooters and showed that experienced shooters were able to stabilize their posture even better during the last seconds preceding the shot.

However, there is no scientific evidence showing stabilometric or balance parameter in rowers. Balance in rowing boats is a really important job for experienced and non-experienced rowers. To solve this possible problem, learning of additional elements of the rowing motion are facilitated (Wagner, Bartmus, & de Marées, 1993). Timing and balance influences muscles recruitment, loading, and ultimately force production (Francis, 2011). During recovery or aerial phase relaxed movements result in a balanced beat. Balance allows rowers to keep their blades off the water and keep the boat from rolling. Any rolling of the boat requires rowers to contract muscles to even out the boat and to stabilize their bodies (Nolte, 2011).

The purpose of this study was to create reference stabilometric values in fixed seat rowing and compare them between male and female rowers in different sensorial conditions, eyes open and closed.

Materials and Methods

Sample

Fifteen subjects voluntarily participated in this study, six male rowers with a mean age of 25.94±5.67 years old and nine female rowers with a mean age 23.11±4.18 years old. This research included rowers who practise fixed seat rowing and were members of the University of Alicante Team. Male rowers and female rowers belong to the senior category, which includes competitors with training experience ranging from 1 to 10 years. During the research, the athletes were in the competitive period.

The mean ± SD characteristics of male rowers were height: 179.02±5.74 cm; weight: 78.10±4.32 kg; BMI: 24.36±1.18 kg/m^2; body muscle: 45.76±2.84 % and body fat: 11.88±3.14 %. The mean ± SD characteristics of female rowers were height: 169.25±5.98 cm; weight: 64.89±7.00 kg; BMI: 22.68±1.92 kg7m^2; body muscle: 38.04±3.07 % and body fat: 14.83±3.17 %. Participants gave their written consent before the start of the study, previously approved by the research ethics committee of the University of Alicante.

Procedure and design

A 555x420 mm FreeMed baropodometric platform (Rome, Italy) was used for the stabilometric measurements, with an active surface of 400x400 mm and 8 mm thickness (Romero-Franco et al., 2015). Postural sway was measured for 30 s while rowers stood in four different stances with eyes open and closed (Brito et al., 2012; Paillard et al., 2002): left monopodal stance, right monopodal stance, bipodal stance (Romero-Franco et al., 2015) and sitting position (Borghuis, Hof, & Lemmink, 2008) because, according to the biomechanical model of technical execution in fixed seat rowing, rowers are sitting on a fixed bench (Penichet-Tomas, Pueo, & Jimenez-Olmedo, 2016). Stabilometric parameters measured to express deviation of the Centre of Pressure (CoP) were: (TE) total excursion of the CoP, defined as the length or the total distance of the CoP over the course of the trial duration; (CEA) area of the 95 % confidence ellipse, smallest ellipse that will cover 95 % of the points of the CoP diagram; (MV) mean velocity, defined as total distance travelled by the CoP over time; and four parameters that measure average absolute displacements around the mean CoP: (MDx) mediolateral direction, (MDy) anteroposterior direction, (RMSx) root-mean-square amplitude in mediolateral direction and (RMSy) root-mean-square amplitude in anteroposterior direction.

Statistical analysis

The Statistical Package for Social Sciences (SPSS) v.22 program was used to compare the means of variables. Shapiro-Wilk statistical test was used to determine whether the quantitative variables fulfil the criterion of normality. The Student t test was used for variables that reached the level of significance (p<0.01), fulfilling the criteria of normality. On the other hand, U-Mann-Whiney test was used for variables that fail to reach the level of significance (p<0.01).

Results

Table 1 shows bipodal stance variables in male and female rowers, with eyes open and closed. Results indicate that male rowers had greater ability to maintain balance than female rowers in bipodal stance with eyes open and closed. However, no significant differences were noted (p<0.05).

Length and area covered by CoP in the male group with eyes open were 370.87±145.47 mm and 42.75±43.66 mm^2, respectively. However, the female group covered 382.53±128.11 mm of length and 113.21±126.41 mm^2 of area. Male rowers length with eyes closed was 397.68±135.56 mm and covered

17.70±14.21 mm^2 of area, versus 407.74±149.78 mm of length and 43.82±32.01 mm^2 of area in the female group with eyes closed. Velocity was very similar in male and female groups.

The mean CoP position in the anteroposterior direction and the amplitude in mediolateral and anteroposterior directions were very similar in male and female groups. However, mediolateral direction in male groups, eyes open and closed, were closer to zero.

Table 1. Bipodal Stance

	Eyes Open				Eyes Closed			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
TE (mm)	370.87	145.47	382.53	128.11	397.68	135.56	407.74	149.78
CEA (mm^2)	42.75	43.66	113.21	126.41	17.70	14.21	43.82	32.01
MV (mm/s)	12.55	4.93	12.83	4.28	13.37	4.52	13.54	4.98
MDx (mm)	-2.72	8.82	-6.08	7.52	-3.5	9.19	-7.19	10.17
MDy (mm)	-17.84	9.32	-17.33	10.14	-14.8	11.67	-16.92	8.27
RMSx (mm)	0.415	0.211	0.449	0.221	0.429	0.195	0.456	0.294
RMSy (mm)	0.399	0.180	0.412	0.126	0.433	0.172	0.487	0.146

TE: total excursion of the CoP; CEA: area of 95 % confidence ellipse; MV: mean velocity; MDx: mediolateral direction; MDy: anteroposterior direction; RMSx: amplitude in mediolateral direction; RMSy: amplitude in anteroposterior direction.

Monopodal stance variables are shown in Table 2 where no significant differences were noted ($p<0.05$). There was no clear trend in relation to a greater balance between male and female.

Length covered by CoP in the female group with eyes closed (left leg: 1715.23±219.75 mm; right leg: 1601.41±412.27 mm) was lower than in the male group (left leg: 1881.60±625.94 mm; right leg: 1916.79±334.28 mm). The area covered by female rowers with eyes open was smaller than area covered by male rowers (left leg: 344.86±221.36 mm^2 vs 415.82±358.93 mm^2; right leg: 406.28±86.91 mm^2 vs 469.81±151.80 mm^2). However, the velocity in the male group with eyes open was lower (19.15±3.62 mm/s vs 21.43±3.94 mm/s with left leg and 19.51±2.05 mm/s vs 19.91±3.60 mm/s with right leg) than in the female group.

The mean CoP position in the mediolateral direction was nearest to zero with both legs in the male group with eyes open, but in the female groups, it was nearest with eyes closed. The amplitude in mediolateral direction was smaller in the female group than in the male group, with eyes open and closed. However, the amplitude in anteroposterior direction in male group with eyes open was smaller than female rowers with left and right legs.

Table 2. Monopodal Stance

	Eyes Open				Eyes Closed			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
TE_L (mm)	666.47	104.78	726.72	125.35	1881.60	625.94	1715.29	219.75
TE_R (mm)	771.35	41.28	765.01	108.08	1916.79	334.28	1601.41	412.27
CEA_L (mm^2)	415.82	358.93	344.86	221.36	3695.38	1965.85	3934.29	4275.05
CEA_R (mm^2)	469.81	151.80	406.28	86.91	4346.82	3862.63	2731.01	1847.41
MV_L (mm/s)	19.15	3.62	21.43	3.94	57.06	6.83	51.92	20.69
MV_R (mm/s)	19.51	2.05	19.91	3.60	0.70	0.39	0.89	0.57
MDx_L (mm)	0.51	3.02	0.96	4.71	-4.61	11.01	-3.17	36.16
MDx_R (mm)	-1.79	2.15	-1.87	5.95	2.45	17.58	0.25	9.75
MDy_L (mm)	-19.34	6.47	-20.37	11.50	-25.61	8.30	-16.44	14.88
MDy_R (mm)	-13.84	5.76	-13.48	8.44	-17.93	11.19	-22.21	7.87
$RMSx_L$ (mm)	3.448	0.621	3.129	0.457	6.443	0.878	5.846	1.235
$RMSx_R$ (mm)	6.801	1.021	6.068	1.084	6.298	1.396	5.241	1.820
$RMSy_L$ (mm)	0.866	0.164	0.970	0.198	2.908	0.570	2.928	1.682
$RMSy_R$ (mm)	1.101	0.297	1.156	0.441	2.820	0.826	2.636	0.989

TE: total excursion of the CoP; CEA: area of 95 % confidence ellipse; MV: mean velocity; MDx: mediolateral direction; MDy: anteroposterior direction; RMSx: amplitude in mediolateral direction; RMSy: amplitude in anteroposterior direction; $_L$: left; $_R$: right.

Finally, Table 3 shows sitting position variables. Female rowers demonstrated more ability to preserve sitting position than male rowers with eyes open and closed.

Length and area covered by CoP in the female group with eyes open were 197.88±72.54 mm and 2.90±1.51 mm^2, respectively. However, the male group covered a length of 261.50±54.74 mm and 4.58±5.24 mm^2 of area. Female rowers' TE length with eyes closed was 205.22±76.47 mm and covered 1.45±0.75 mm^2 of area, versus 267.66±149.78 mm of length and 2.69±1.89 mm^2 of area in the male group with eyes closed. Furthermore, velocity in female groups was 6.70±2.54 mm/s with eyes open and 6.93±2.69 mm/s with eyes closed, while in male groups, it was 8.82±1.87 mm/s with eyes open and 8.99±2.30 mm/s with eyes closed.

The mean CoP position in the mediolateral direction was closest to zero in male groups than in female groups. However, mean CoP position in anteroposterior direction was closest to zero in female groups than in male groups. Results show statistical differences (p<0.05) in mediolateral direction amplitude between female and male groups, both with eyes open and closed. The amplitude in mediolateral direction of female rowers was 0.229±0.075 mm with eyes open and 0.231±0.075 mm with eyes closed. However, the amplitude in mediolateral direction of male rowers was 0.324±0.050 mm with eyes open and 0.321±0.028 mm with eyes closed. The amplitude in anteroposterior direction was smaller in female rowers too.

Table 3. Sitting Position.

	Eyes Open				Eyes Closed			
	Male		Female		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
TE (mm)	261.50	54.74	197.88	72.54	267.66	65.34	205.22	76.47
CEA (mm^2)	4.58	5.24	2.90	1.51	2.69	1.89	1.45	0.75
MV (mm/s)	8.82	1.87	6.70	2.54	8.99	2.30	6.93	2.69
MDx (mm)	2.51	4.01	4.19	10.69	2.44	3.59	3.13	8.85
MDy (mm)	-13.89	9.36	-7.50	13.56	-15.85	8.12	-13.61	7.76
RMSx (mm)	0.324	0.050	0.229 *	0.075	0.321	0.028	0.231 *	0.075
RMSy (mm)	0.230	0.120	0.194	0.103	0.265	0.141	0.216	0.115

TE: total excursion of the CoP; CEA: area of 95 % confidence ellipse; MV: mean velocity; MDx: mediolateral direction; MDy: anteroposterior direction; RMSx: amplitude in mediolateral direction; RMSy: amplitude in anteroposterior direction; *: significance p<0.05.

Discussion

The objective of this study was to create reference stabilometric values in fixed seat rowing and compare them between male and female rowers in different sensorial conditions, eyes open and closed. A reduced base of support or deprived visual control results in a longer postural sway (Amiridis, Hatzitaki, & Arabatzi, 2003; Muehlbauer et al., 2012). The centre of pressure and its derivatives are the most frequent dependent variables used in research (Palmieri et al., 2002). Literature proposes that an increase in total distance travelled by the centre of pressure represents a decreased ability by the postural-control system to maintain balance (Holme et al., 1999).

Results indicate that male rowers had greater ability to maintain balance than female rowers in bipodal stance. If we consider that male rowers had a higher BMI (24.36±1.18 kg/m^2) and body muscle (45.76±2.84 %) in this study than female rowers (22.68±1.92 kg7m^2 if BMI and 38.04±3.07 % of body muscle), we could confirm that this results agree with the study of Angyán et al. (2007) who concluded that increase in BMI and muscle strength is associated with better postural stability.

In this study, there was no clear trend in relation to a greater balance between male and female in monopodal stance. Unlike other sports, both legs are executed simultaneously in rowing, during the technical execution of the stroke (Penichet-Tomas et al., 2016). Therefore, the lack of balance may be due to the inability to execute motor functions by leg. Furthermore, many people have problems standing on one leg for a period of time, specially when an additional sensory system that functions to maintain balance is hindered (Palmieri et al., 2002). According with this result, Hahn et al. (1999) were not able to find relationships between mean of the maximum time of one-legged balance and sex in their study about one-leg standing balance in different sports activities. However, Ageberg, Zatterstrom, Friden, & Moritz (2001) found differences between men and women. In their study about individual factor affecting stabilometry, they showed that average speed was higher in men than in women.

Results in length, area, velocity and root-mean-square amplitude showed that female rowers demonstrated more ability to preserve sitting position than male rowers. In this case, a decrease in RMS amplitude means an increased ability to preserve an upright stance (Geurts, Nienhuis, & Mulder, 1993). Furthermore, mediolateral direction amplitude was statistically significant (p<0.05) between male (0.324±0.050 mm with eyes open and 0.321±0.028 mm with eyes closed) and female (0.229±0.075 mm with eyes open and 0.231±0.075 mm with eyes closed) in this study. Borghuis et al. (2008) found a significant correlation between poor balance performance in a sitting balance task and delayed firing of the trunk muscles during sudden perturbation. These results suggested that male rowers could have more proprioceptive deficits than women. Although the specific modalities of postural regulation developed with sport training are not always transferable to upright stance situations (Asseman et al., 2004), Ageberg et al. (2001) also observed differences between men and women in stabilometry, in which females showed better balance function than males.

Conclusions

Male rowers had greater ability to maintain balance than female rowers in bipodal stance, with eyes open and closed. However, there was no clear trend in relation to a greater balance between men and women in monopodal stance. Female rowers demonstrated more ability to preserve sitting position than male rowers, with eyes open and closed. Length, area and velocity of the CoP in female groups were smaller than in male groups. The amplitude in mediolateral and anteroposterior direction in female groups also was smaller.

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