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Intra- and inter-somatotype differences in a manual material handling task

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The Manual Material Handling (MMH) of loads is considered worldwide one of the main components in musculoskeletal disorders in various industries, which also carries a high cost [1]. Prior research has shown that there are limited studies comparing different bodily characteristics for both genders during MMH [4] and that individuals severely obese are in greater risk than normal weight individuals when performing a MMH task [5].

A total of 37 subjects were assessed for this study, each subject signed an informed consent form and anthropometric measures were taken in addition to age, weight, and height, using a skinfold caliper. Table 1 summarizes the somatotype (endomorph: soft round body type, mesomorph: athletic body type) data according to each gender, based on Heath-Carter formula.

Table 1. Average (standard deviation) of the participants according to their somatotype

	Mesomorph (athletic body type)		**Endomorph (gain weight easily)**	
Gender	**Male n=16**	**Female n=10**	**Male n=3**	**Female n=8**
Age (years)	23.50 (3.69)	22.30 (2.54)	21.33 (2.52)	21.71 (1.11)
Weight (kg)	68.51 (5.77)	63. 17 (13.43)	78.97 (5.44)	64.31 (11.15)
Height (cm)	171.33 (6.89)	159.63 (5.29)	175.87 (2.11)	162.41 (5.45)
BMI	23.26 (1.73)	24.66 (4.33)	25.51 (1.19)	24.23 (9.14)
FAT %	19.21 (0.04)	22.68 (0.04)	24.46 (0.01)	33.39 (0.00)

The kinematic data were recorded with Qualisys motion capture system (Stockholm, Sweden), with 8 Miqus M1 and 1 Miqus Video cameras, at 150 frames per second. A total of 57 passive markers were used. The data was analyzed and processed on Visual 3D software (C-Motion, Inc, MD, USA), using an inter-linked segments model. The kinematic data was processed and filtered using a fourth-order, bidirectional, low-pass Butterworth filter, with cutoff frequencies of 6 Hz.

A 15.0 kg load was lifted from a height of 15 cm above ground level and unloaded at shoulder height (relative to each person), the load was lifted twice, with an interval of 30 seconds between each series. In addition, two different lifting conditions were carried out, without any instructions (free condition) for each participant, and then with specific instructions (instructed condition) for an appropriate MMH, based on [2] and [3].

Endomorph female participants presented an increased trunk-lab angle during the free condition compared to instructed trials (74.50° vs 49.39°, respectively, $t = 4.48$, $df = 10$,

$p < 0.05$, $r = 0.82$). In the case of female mesomorph participants, trunk-pelvis and trunk-lab angles were higher for the free condition compared to the instructed trials ($r = 0.79$, $r = 0.82$, respectively), and on the contrary knee and ankle joint angles were lower ($r > 0.50$ in both cases). Fig. 1(a) shows this situation in a schematic representation from one of the participants for both conditions.

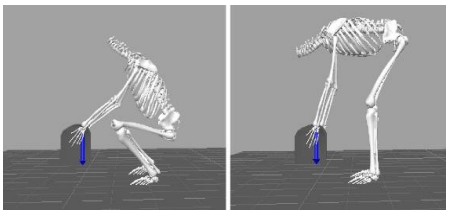
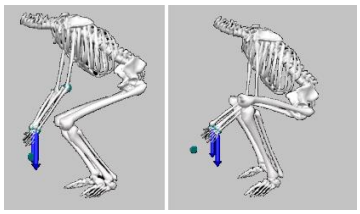
a)  b) 

Fig. 1. a) Lift start visualization for one endomorph female, instructed (left) vs. free. b) Inter-somatotype differences for the 15-kg load on instructed trials, endomorph (left) vs. mesomorph

A similar behavior was presented on mesomorph male participants, where knee, hip, trunk-pelvis and trunk-lab angles were significantly different ($t = 4.35$, $df = 24$, $p < 0.05$, $r = 0.66$; $t = -3.17$, $df = 24$, $p < 0.05$, $r = 0.54$; $t = -3.13$, $df = 24$, $p < 0.05$, $r = 0.54$, and $t = -4.42$, $df = 12$, $p < 0.05$, $r = 0.79$, respectively). Endomorph male participants did not show any statistical differences.

Concerning inter somatotypes differences (mesomorph vs endomorph) for the instructed condition, no differences were found from a statistical point of view ($p > 0.05$). Nevertheless, male mesomorphs bent more the hips (106.86° vs 88.00°) and presented a more extended trunk-pelvis angle (-33.17° vs -56.20°), though mesomorph male participants performed a marginally more extended trunk inclination (42.94° vs 46.53°). Fig. 1(b) exhibits inter-somatotype differences. This might be attributed to a stronger body composition on mesomorph participants compared to endomorph.

In conclusion, when subjects executed free trials, they bent their knees less than following lifting instructions, leading to a greater trunk inclination to reach the load. On the other hand, despite instructions were given, small inter-somatotypes variations were found in instructed trials, however, these differences were not significant.

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References

[1] Haines, T., Bowles, K., Cost-effectiveness of using a motion-sensor biofeedback treatment approach for the management of sub-acute or chronic low back pain: Economic evaluation alongside a randomized trial, BMC Musculoskeletal Disorders 18 (1) (2017).
[2] Kingma, I., Faber, G., Van Dieën, J., How to lift a box that is too large to fit between the knees, Ergonomics 53 (10) (2010) 1228-1238.
[3] Kingma, I., Faber, G., Van Dieën, J., Supporting the upper body with the hand on the thigh reduces back loading during lifting, Journal of Biomechanics 49 (6) (2016) 881-889.
[4] Plamondon, A., Lariviere, C., Denis, D., St-Vincent, M., Delisle, A., Sex differences in lifting strategies during a repetitive palletizing task, Applied Ergonomics 45 (6) (2014) 1558-1569.
[5] Singh, D., Park, W., Hwang, D., Levy, M., Severe obesity effect on low back biomechanical stress of manual load lifting, Work 51 (2) (2015) 337-348.