ARE BIOMECHANICAL MEASUREMENTS "DEFORMED" WHEN SUBJECTS ARE INFORMED? AN ILLUSTRATION IN HUMAN RUNNING

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INTRODUCTION

We sought to determine whether, as often observed in medical protocols studying drugs-patients relationships [1], informing subjects on the measurements performed (moment of sampling, nature of the exact parameter(s) studied), affected their behaviour, in this case their running pattern. We used actual and deceptive instructions in a standard running protocol, and studied runners' stride mechanics through the spring-mass model, using lower limb stiffness (k_{leg}) as the key parameter.

METHODS

Fourteen male physical education students (21.9 ± 3.3 years; 73.2 ± 8.6 kg; 1.78 ± 0.09 m) all familiar with treadmill running (but not specialised in running) volunteered to report individually to the laboratory, and to run at 12 km.h^{-1} for a 6-min warm-up, followed by four more minutes during which two 20-s samples of data were announced to subjects and recorded. Beyond these actual instructions, hidden samples were recorded discretely every minute during the warm-up and at four moments over the four following minutes, subjects being aware of only two of them. This allowed us to set five different levels of subjects' awareness and expectations about what was really being, or about to be measured. A_1: subjects thought nothing was being measured (samples *WU1* to *WU6*); A_2: they knew a measurement (of an unknown parameter) was coming (sample *M1*); A_3: they knew a measurement (of an unknown parameter) was in progress (sample *M2*); A_4: they knew a measurement was coming, and they also knew what was about to be observed: "stride dynamics and lower limbs stiffness" (sample *M3*); A_5: they knew a measurement was in progress, and they also knew what was being observed (sample *M4*). Subjects were only *informed* about the parameter studied, and absolutely not (explicitly or implicitly) *required* to run and modify it, the last words of each information message were "run normally". We chose "stride dynamics" and k_{leg} as the key parameter mentioned to subjects because it was 1) enough sensitive to voluntary motor control to significantly change when subjects intentionally want to [2], and 2) rather positively (from a running technique point of view) considered in the collective unconscious of the population tested. Mechanical parameters were measured for each step using a treadmill dynamometer (ADAL, HEF Tecmachine, Andrézieux-Bouthéon, France) [3]. Vertical ground reaction force (*VGRF*) data were sampled at 1000 Hz for 10 consecutive steps and used to compute contact (*tc*) and aerial (*ta*) times, step frequency (*f*), k_{leg} , which was calculated as $k_{leg} = F_{max}.\Delta L^{-1}$ with F_{max} the peak *VGRF* and ΔL the maximum leg spring compression, as per [2].

RESULTS AND DISCUSSION

ANOVAs for repeated measures showed that none of the mechanical parameters changed over the six samplings in A_1 condition (samples *WU1* to *WU6*). However, the level of awareness and information given had a significant effect on the running pattern for most of the parameters, as summarized in Table 1. For instance, k_{leg} significantly increased (on average by 3.48 %; $p < 0.001$), between *M2* and *M4*: subjects tended to increase k_{leg} when they knew this parameter was being specifically studied, and the very moment it was sampled. Our results show that subjects did not behave (run here) the same when 1) knowing a sampling was in progress and 2) knowing *what* was studied. The amount of k_{leg} change was rather substantial since a re-test protocol showed that the "unconscious" change equated about half of that observed when explicitly asking these subjects to run increasing k_{leg}. Our most likely psychological explanation is that subjects tended to be conditioned by the informations given, and that their expectancies influenced their behaviour [4], *i.e.* in our case their locomotion pattern. These results may have implications in the field of locomotion biomechanics, when informing subjects on the very moments of mechanical samplings and on the nature of the parameters(s) tested, or worst, on the changes expected in the various experimental conditions proposed.

CONCLUSIONS

Informing subjects may induce changes in their locomotion pattern (here running), hence experimental biases. Consequently, if confirmed, we do think this potential bias should be taken into account (whenever possible) when designing biomechanical experiments.

REFERENCES

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Table 1: Mean (SD) of the main mechanical parameters for the five increasing levels of awareness and expectations.

Parameter	Experimental condition and sample name					
	WU6	*M1*	*M2*	*M3*	*M4*	*Re-test**
tc (s)	0.237 (0.016)	0.240^{c,d} (0.014)	0.238^{d} (0.017)	0.235 (0.017)	0.235 (0.017)	0.222 (0.012)
f (Hz)	2.80^{b,d} (0.15)	2.80^{d} (0.16)	2.83 (0.17)	2.81^{d} (0.16)	2.84 (0.17)	2.81 (0.20)
F_{max} (N)	1874 (232)	1850 (270)	1860 (262)	1873 (246)	1879 (247)	1973 (234)
ΔL (m)	0.113^{a,d} (0.014)	0.115^{b,c,d}	0.113^{d} (0.015)	0.111 (0.015)	0.108 (0.09)	0.11 (0.015)
k_{leg} (kN.m^{-1})	16.9^{a,d} (3.02)	16.3^{b,c,d} (3.40)	16.9^{d} (3.53)	17.3 (3.48)	17.4 (3.47)	18.8 (2.89)

*: During a second session (9 months after the first one), 8 subjects from the first protocol were explicitely asked to run with a high k_{leg}

[a]: significantly different from *M1* [b]: significantly different from *M2* [c]: significantly different from *M3* [d]: significantly different from *M4*