BIOMECHANICAL ANALYSIS OF THE EFFECT OF COMPRESSION SPORTSWEAR ON RUNNING

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1. Introduction

One of the most crucial factors in the design process is the comfort of clothing which is resulted of many interactions between physical and physiological factors. Our body maintain its comfort state by evaporating moisture to cause cooling, while the clothing could form a heat and vapor transmission barrier. Therefore, the ideal sportswear should be able to transport sweated water without feeling ourselves wet [1].

The aim of this present research was to compare a commercial compression sportwear with two different custom-made garments by applying biomechanical measurements. For this purpose, a complex measurement system was constructed, moreover, a pilot study was executed involving 4 female participants. According to MacRae et al. in terms of compression garments' efficiency in exercises, they can reduce oscillation and increase strength enhancing the performance [2]. Therefore, the different sportswear had the same cut and similar material composition but had different compression.

2. Materials and methodology

2.1 Investigated sportswear

Firstly, a purchased sportswear (P1) was tested which has been bought ready-made for all participants in the pilot-study. Secondary, the custom-made garments were prepared based on 53 different previously measured sizes. The first garment (CM-1) was made with body size below of 1% however, the second (CM-2) with body size below of 5 %. Body size below means that in the pattern circumferences were reduced by the given percentage to achieve different compression. Based on MacRae et al. the level of pressurization is a significant variable in compression garments [2]. Therefore, the compression of the different clothing was measured with a Picopress compression probe. These values are summarized in Tab 1. for the most relevant body segments.

Table 1. Measured compression values.

Name	Calves [Hgmm]	Knee [Hgmm]	Thigh [Hgmm]	Waist [Hgmm]	Crop [Hgmm]
P1	15	7.5	9	17.5	3.5
CM-1	7	5	7.5	9	2
CM-2	10.5	6.5	6	10.5	3.5

2.2 Measurement setup

The first goal of this present research was to construct a complex biomechanical measurement system through which the sportswears are comparable. The final setup is depicted in Fig. 1. As we can see on the figure three different measurement were carried out simultaneously. The motion was recorded with an Optitrack (*NaturalPoint, Inc*., Oregon, USA) based motion capture system with 120 Hz sampling frequency. In parallel with the motion analysis body temperature was captured with 8 FPS with the help of a Flir type (*Flir System*, Oregon, USA) thermometry. Moreover, the heart rate (HR) was monitored with the help of a Garmin Forerunner 310XT (*Garmin Ltd*., Kansas, USA) sport watch and its heart rate monitor strap.

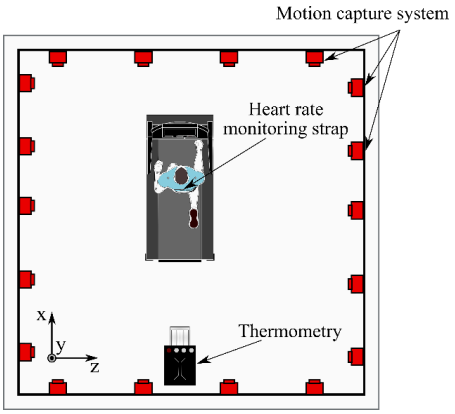

Fig. 1. Measurement setup.

2.3 Pilot-study

During the investigation a pilot-study was executed involving four healthy, well-trained female free-time runners (age: 21.0 ± 2.2 yrs, body mass: 63.3 ± 2.1 kg, height: 170.5 ± 2.5 cm). None of the participants had suffered from any injury

which affects to the locomotion system. The experimentation was performed on a treadmill applying gradually increasing velocity intervals. After 3 minutes of walking the following velocities were considered: 7 km/h, 8 km/h, 10 km/h, 11 km/h. The participants ran 3 minutes in each period without any break.

2.4 Data analysis

Applying the 3D position data of the 39 anatomical landmarks the angular and geometrical parameters could be calculated using an open-source software OpenSim (*NIH Center for Biomedical Computation*, Stanford, USA). Afterwards, a self-developed Matlab (R2017a, *The MathWorks*, Massachusetts, USA) script was utilized to split the motion into gait cycles and determine the relevant gait parameters. In this study the range of motion of knee extension (ROM_{knee}), the range of motion of hip extension (ROM_{hip}), the vertical displacement of center of mass (COM_y) and the step length were considered. The gait parameters were evaluated for the last 60 seconds of the velocity intervals. In case of hart rate measurements at least a 120 seconds interval is necessary to obtain a motion specific HR value [3]. Therefore, the measured HR values were averaged on the whole period (Table 2). Finally, 5 selected body segments' temperature were determined with the help of the data from the thermometry. The specific temperature (ΔT) of the different region were calculated from the measured values by normalizing the with a measured free surface's temperature (for the tight and waist region see on Fig. 3).

3. Results

The secondary aim of the research was to compare the different sportswear based on the pilot-study. Therefore, one-sample t-test was performed pairwise with significance level of 0.05. The result of the statistic probe is summarized in Fig. 2.

	Step lenght [m]				COM_y [m]		ROM_{knee} [°]				ROM_{hip} [°]			
	right		left				right		left		right		left	
	avg	CV	avg	CV	avg	CV	avg	CV	avg	CV	avg	CV	avg	CV
P1 vs CM-1														
7 [km/h]														
8 [km/h]														
10 [km/h]														
11 [km/h]														
P1 vs CM-2														
7 [km/h]														
8 [km/h]														
10 [km/h]														
11 [km/h]														
CM-1 vs CM-2														
7 [km/h]														
8 [km/h]														
10 [km/h]														
11 [km/h]														

Fig. 2. Significant differences (marked with red cells) in between the gait parameters.

Table 2. Measured heart rate values.

	heart rate [BMP]			
	7 [kmh^{-1}]	**8 [kmh^{-1}]**	**10[kmh^{-1}]**	**11[kmh^{-1}]**
P1	143 ±8	164 ±12	176 ±10	185 ±9
CM-1	140 ±12	160 ±14	173 ±12	182 ±11
CM-2	134 ±10	155 ±10	168 ±11	176 ±10

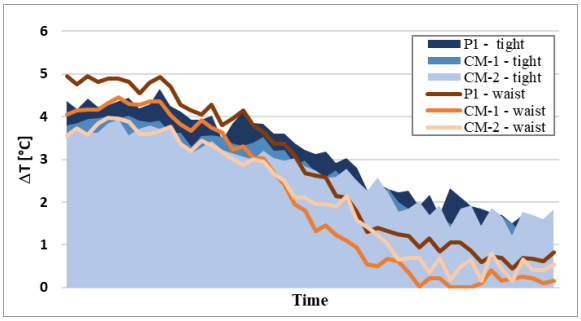

Fig. 3. Change of specific temperatures.

As a result of the pilot-study some remarks can be concluded. Firstly, in case of CM-2 garment the HR values are significantly smaller than the other two sportswear (see on Table 2). On the other hand, despite of different compression values e.g. in the tight and waist regions, the change of specific temperature data shows similar tendency (see on Fig. 3). Moreover, many of the significant differences were obtained in between the purchased (P1) and CM-2 garment in term of the gait parameters (see on Fig. 2) which pressure values are close to each other in the lower regions (Table 1).

4. Conclusions

To sum up, the compression of different running suit didn't necessarily influence the biomechanical parameters. Whereas, based on the HR results the custom-made design and the grater pressurization might improve the blood circulation and lead to smaller HR values.

Acknowledgements

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