The Influence of Pelvic–Belt Design on Backpack Stability in Mountain Biking

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Introduction

Backpack stability is determining the comfort of bike backpacks. In mountain biking large vibrations occur (Macdermid et al., 2014), get transferred to the rider and cause undesired backpack wobbling, which can disturb rider's balance. The pelvic belt is attributed to provide the necessary stability and is therefore a common feature amongst modern bike backpacks (Frey, 2019). Recent research show that a pelvic belt reduces the backpack wobbling while mountain biking (Höschler et al. 2021), but is not needed for stabilization when road cycling (Campos et al., 2020). These findings indicate that bike backpacks worn by commuters and occasional mountain bikers incorporate a pelvic belt that is rarely needed.

A potential solution could be the development of an innovative roll-up belt, that can be fastened when needed and that easily rolls up in the backpack (patent pending). In order to develop a functional roll-up belt the influence of basic belt characteristics as elastic properties, retraction force and contact area must be determined.

The goals of this study were to compare the effect of different pelvic belts on backpack stability in mountain biking, to test the potential of roll-up belts and to derive findings for further backpack development

Materials & Methods

Belt Modifications: Three models of a conventional bike backpack (VAUDE Ledro 18 L) were modified. One belt consisted of two elastic bands (width 50 mm) connected by Velcro (EB, **Fig. 1 a**). The two other backpacks were modified with roll-up belts. One was equipped with a conventional seatbelt (width 47 mm, DIN EN ISO 6683) with an auto-block mechanism (SB, **Fig. 1 b**). For the other a spring balancer with thin cord (diameter 2 mm, MOLEX) and adjustable retraction force (set to 5 and 20 N) was used (SPRING5/20, **Fig. 1 c**). An unmodified bike backpack (VAUDE Moab II 16L) with a conventional pelvic belt served as comparison (CB, **Fig. 1 d**). All backpacks were filled and loaded with 4 kg additional weight.

Fig. 1: Belt conditions: a) Elastic Band (EB), b) Seatbelt (SB), c) Spring balancer (SPRING5 & SPRING20), d) Conventional Belt (CB).

Set-Up: Healthy male recreational cyclists (n=11) used a 29" hard-tail MTB (Centurion Backfire) to ride over an uneven ramp (length 2.5 m, height 0.3 m) while wearing the different backpacks **(Fig. 2)**.

Triaxial IMUs (fs = 2000 Hz, Myon Aktos) were used to measure the accelerations of rider and backpack during 5 trials. 2 IMUs were placed on the upper and lower spine (C7, SACRUM). Two corresponding IMUs were fixed inside the backpack at the upper and lower end of the back plate (TOP, BOTTOM).

Data Analysis: A Matlab script (R2020a, The MathWorks) was used for data analysis. The regional backpack wobbling (BPW) was calculated as the ratio between the integrated resultant acceleration of the backpack segment and the corresponding body position (TOP/C7, BOTTOM/SACRUM) averaged over 5 trials. For statistical analysis, the paired t-test (p=0.05) was used.

Fig. 2: a) Experimental set-up: Subject biking over the ramp. b) Visible backpack displacement indicated by white stripes

Results

The BPW values of the top and bottom region for the different belt conditions are shown in **Figure 3**. Ratios > 1 indicate higher accelerations of the backpack compared to the corresponding body position (backpack wobbling).

There were no significant differences found between the belts for the BPW at the top region. Regarding the bottom region, the CB condition had significantly smaller BPW values than EB (p=0.003), SB (p=0.011), SPRING5 (p=0.002) and SPRING20 (p=0.001). Of the roll-up belts, SB showed less BPW than SPRING5 (p=0.035) and SPRING20 (p=0.036). There were no significant differences between the two spring conditions (p=0.489).

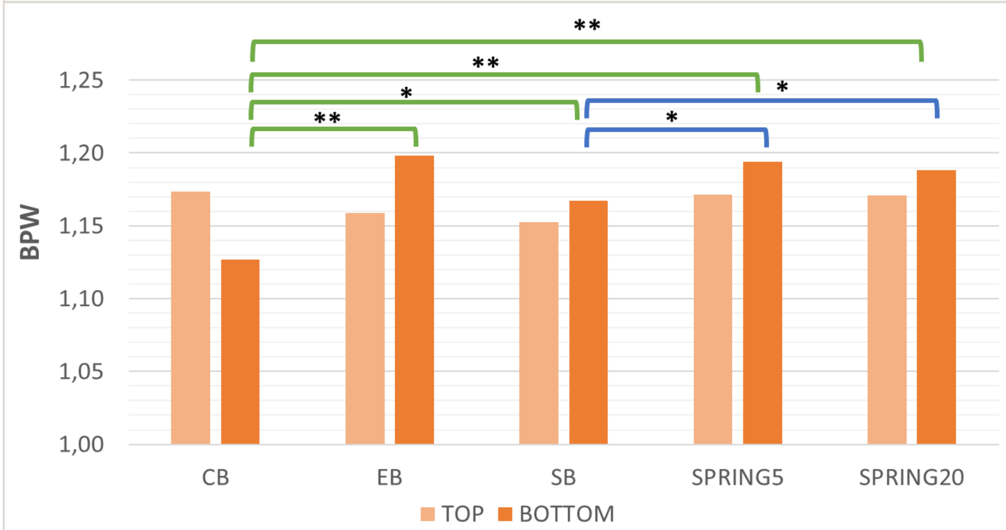

Fig. 3: Regional Backpack Wobbling (BPW) of the different belts. Conventional belt (CB), elastic band (EB), seatbelt (SB), spring balancer at 5 and 20 N (SPRING5, SPRING20). * p < 0.05, ** p < 0.01.

Discussion & Practical Applications

The modified belts could not stabilize the backpack to the same amount as the conventional belt. In agreement with previous findings the backpack stability in the top region was not influenced by the pelvic belts (Höschler et al., 2021).

Belts made of elastic materials do not provide adequate stability for mountain biking. Pelvic belts should be manufactured of somewhat stiff material or use a combination of stiff and elastic materials.

Comparing the roll-up belts, the seat belt provided greater stability than the spring balancer presumably caused by the larger contact area, frictional properties, or the blocking mechanism. No differences in stability were found between the two spring forces, indicating that there is no increase in stability with higher strap forces for thin belts.

Subjects reported a low overall comfort of the SB caused by continuous blocking and abdominal compression. The spring balancer was assessed more comfortable for being inconspicuous, lightweight and barely noticeable.

Roll-up belts are a promising feature for bike backpacks by providing some degree of stability and can be easily stored when not needed. If further improved, an ideal roll-up belt could be advantageous with regards to adjustable backpack stability, unhindered abdominal respiration, improved thermal comfort around the lower back and pelvis region as well as ergonomics and handling respectively.

Future studies should focus on understanding the role of friction on backpack stability and compare the thermal comfort of different pelvic belts.

References

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