

REVIEWER 1

Open Review

- (x) I would not like to sign my review report
() I would like to sign my review report

English language and style

- () Extensive editing of English language and style required
() Moderate English changes required
(x) English language and style are fine/minor spell check required
() I don't feel qualified to judge about the English language and style

	Yes	Can be improved	Must be improved	Not applicable
Does the introduction provide sufficient background and include all relevant references?	()	(x)	()	()
Is the research design appropriate?	()	(x)	()	()
Are the methods adequately described?	()	(x)	()	()
Are the results clearly presented?	()	(x)	()	()
Are the conclusions supported by the results?	()	(x)	()	()

Comments and Suggestions for Authors

The article is focused on the influence of asymmetry of biomechanical variables on several aspects of alpine skiing slalom. Kinematics and GRF were collected on skiers performing a series of turns starting either on the right or on the left of the track. The symmetry coefficient and Jaccard index were assessed for a combination of independent variables (IV, biomechanical parameters) related to dependant variables (DV, performance variables). Multiple linear regressions were used to evaluate the relationship between IV and DV.

What is the hypothesis, does asymmetry is detrimental or beneficial to the performance? What is the interest to study the asymmetry of performance?

Reply to the reviewer: We now include the following formulation: "Our hypothesis was that asymmetries in the performance of elite slalom skiers are influenced by asymmetries in their technique and ground reaction forces." In practical terms, we believe that changing less effective turns (e.g., left turns) to more closely resemble the more effective turns (e.g., in this example the right turns) should help optimize a skier's overall performance. However, this remains to be tested employing a different study design.

Since whole body kinematics was recorded, did you consider other joint angles than that corresponding to flexion. At the hip, in particular, abduction-adduction could be of interest? Same remark for the trunk and upper body.

Reply to the reviewer: We did consider other joint angles as well, including all three Euler joint angles at the knee and hip, as well as the inclination of the trunk. Previous findings (Zorko et al. 2013) have demonstrated that the "visual abduction" in terms of 3D joint angles involves true "Euler angle" abduction and a combination of flexion and external rotation (or, more precisely, lower internal rotation). In our opinion, this visual abduction is the observation of most relevance to understanding the biomechanics of alpine skiing. The same is true for the hip angles.

Moreover, angles at the knee joint are particularly complicated by the associated degrees of freedom (Lu et al 2008, Wilson et al 200), so that these angles must be monitored with great care and appropriate

statistical analysis and interpretation performed. In addition, it is uncertain whether the differences (asymmetries) in the angles of abduction and rotation are sufficiently large to allow accurate measurement, since with all kinematic systems, including IMUs, the errors involved in measurement of these angles are more pronounced than when determining flexion (the problem of the order in which the Euler angles should be calculated).

Finally, the inclination of CoM in combination with knee and hip joint angles are reflected directly in the ground reaction forces and angle of the shank, which were analysed here. Similarly, most of the inclination of the trunk of alpine skiers is usually reflected in the distribution of pressure between the forefoot and rearfoot, which was also analysed.

These are the primary reasons why we did not analyse the parameters mentioned in this comment by the reviewer.

Line 54: "Although the body movements of athletes, and especially those of elite alpine skiers when turning, are often asymmetric" Please define what you mean by asymmetry, it could be asymmetry between the inside and outside leg for example.

Reply to the reviewer: This sentence has been revised to indicate more clearly that we are focusing on differences between left and right turns.

Line 95 : "In addition, the skier's boots were equipped with pressure insoles (Loadsol, Novel GmbH, Munich, Germany) that assessed the total ground reaction force, the individual forces acting on the entire inside and outside foot, and the distribution of force between the fore- and rear-foot." By total GRF do you mean the 3D vector? Please clarify.

Reply to the reviewer: We only measured the component perpendicular to the sole of the ski-boot, as now clarified.

Line 130: "As an indicator of overall (as opposed to average) asymmetries throughout the entire turn, the Jaccard index (JI) [27] was also calculated". Could you provide some guidelines on what the values mean? For example, does a JI = 50% means little of great asymmetry?

Reply to the reviewer: We now provide some description of what JI means in practice, explaining the two most extreme cases, i.e., when JI = 1 or 0.

Line 140: "Outliers were excluded from further analysis" On which basis data were considered to be outliers?

Reply to the reviewer: Outliers were determined by application of Tukey's fences, a standard non-parametric procedure for the detection of outliers. With this procedure, a "fence" boundary at a distance of 1.5 IQR (Inter Quartile Range) from the 1st and 3rd quartiles is created and any data outside these fences are considered outliers. This detection is now explained in greater detail.

Line 150: "... indices for the independent variables (skiing technique and ground reaction forces)". It does not seem to me that GRF is an independent variable since it is depending on each subject.

Reply to the reviewer: In this context, the independent variables in the multivariable linear regression models are those that are considered independent in connection with statistical analysis. At the same time, all descriptive statistical parameters related to the ground reaction forces are expressed as % BW (body weight) and are thereby also independent of the skier's weight. This is also the case for the indices of symmetry, if this was of concern.

Line 155: "as well as a tendency towards a statistically significant difference in flexion of the outside knee ($p = 0.11$).". The difference is significant or not according to the chosen significant level for p .

Reply to the reviewer: This part of the sentence has been deleted.

Lien176: "The mean angle of the outside shank during left and right turns differed visually during the entire steering phase" What do you mean by visually?

Reply to the reviewer: This sentence has been revised to describe more precisely what we mean by "visually".

Line 192: "Our multi-variable regression models" Could you please be more precise, what kind of multivariable regression?

Reply to the reviewer: For added clarity, we have revised this text to read "...linear regression models, each involving no more than 2 predictor (independent) variables,..."

Line 194: "(t-statistic, $p < 0.05$)" Would it be rather $p > 0.05$?

Reply to the reviewer: In this case, $p < 0.05$ is correct, since this p-value represents the t-statistic for the hypothesis that the coefficients of the corresponding model did not differ significantly from zero. In practice, this test was applied to eliminate such models. This sentence has also been revised for greater clarity.

Line 198: "SI values for instantaneous and sectional performance" Please define what is instantaneous and sectional performance.

Reply to the reviewer: We now define instantaneous and sectional performance as suggested, with additional explanation also in the Methods.

Line 207-208: Table 3: How do you explain the difference in regression models for SI and JI for the same parameter, the turning radius?

Reply to the reviewer: These are both associated with the GRF, but the SI for turning radius is associated with the SI for GRF and the JI for turning radius with JI for GRF. Moreover, the JI for shank angle is involved only in the model used to predict the JI for turning radius. Apparently, according to our multivariable regression model, the behaviour (JI) of the shank angle during turning also predicted the behaviour (JI) of the turning radius. In contrast, this was not the case for parameters based on mean values (e.g., SI values for turns). In this context we are unable at present to explain the negative association between the JI for hip flexion and SI for turning radius. Consideration of this aspect of our study in the Discussion has now been expanded upon.

Line 225: "(ii) asymmetry in turning radius demonstrated the largest predictor coefficients for asymmetry in the angle of the shank and GRF on the entire foot of the outside leg." If considering SI. If JI is considered the hip flexion seems also to be important.

Reply to the reviewer: We only list the variables associated with the largest predictor coefficients, therefore leaving out the substantially lower and negative (coefficient) association between hip flexion and turning radius (model #4, Table 3). An additional reason for not including this among our major findings is that at present, we are unable to provide a reasonable explanation for this negative association, which indicates that the less pronounced asymmetry in flexion of the outside hip, the greater the asymmetry in turning radius. We now consider this more extensively in the Discussion.

Line 277: "(e.g., the attack angle defines as the angle between the longitudinal axis of the ski and the ski's centre point's velocity vector projected onto a plane parallel to the surface of the snow) [14])" "angle defined" instead of "angle defines"

Reply to the reviewer: Revised as indicated.

25 Sep 2020 14:54:30

Date of this review