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Error amplification strategy for correcting the technical error

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INTRODUCTION

Technical errors are very common among athletes and due to the ability of athletes to compensate, these errors are often part of the final performance.

These errors are not easy to identify

Organism constraints

Environmental constraints

Skill task constraints

The difference between these constraints and the technical errors must be identified and corrected because they may be the cause of a decrease in performance and an increase in the possibility of injury.

Developing methods aimed at improving motor skills and correcting technical errors in sports is a key factor in movement science.

INTRODUCTION

Traditional methods of coaching are based on delivering direct verbal instruction (McCullagh and Weiss, 2001; Horn et al., 2002)

- Descriptive feedback
- Prescriptive feedback
- Augmented feedback (KR and KP)

To practice motor error to strengthen motor learning (Diedrichsen et al., 2010)

- 'Negative practice' (Sharp, 1988);
- The metacognitive learning strategy called 'Old way/New way' (Hanin et al 2002, 2004);
- The 'Method of Amplification of Error' (Cesari & Milanese, 1995; Milanese et al 2008, 2015).

METHOD OF AMPLIFICATION OF ERROR
- MAE -

Milanese et al., 2008, 2015; Corte et al., 2015

What can a subject learn from mistakes?

MAE is based on the assumption that subjects can learn to correct their own movements through an exploration of their mistakes.

Forced exaggeration of the error allows the learner to understand the effects of the error on the outcome and modify his movement accordingly. The amplified trial guides the learner to focusing their attention on the movement effects and not on the movement itself.

Amplified error trial

- new intrinsic feedback
- stimulates the functions of perceptive categorization
- conceptual and symbolic elaboration of the received information.
- better understand WHAT SHOULD NOT BE DONE

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Differential effects of main error correction versus secondary error correction on motor pattern of running

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This study underlines how the classification of technical errors in sport could be a useful tool in diagnosing problems in technique.

The innovative aspect of this study is to take qualitative observation of error and quantitative measurement of improved motor pattern

AIM

The aim of this study was to understand which errors, when corrected, have the greatest effect on improving the run pattern. This allows us to prioritize certain errors over others.

The focus was on the distance between the heel and the vertical projection of the COM at the foot touchdown.

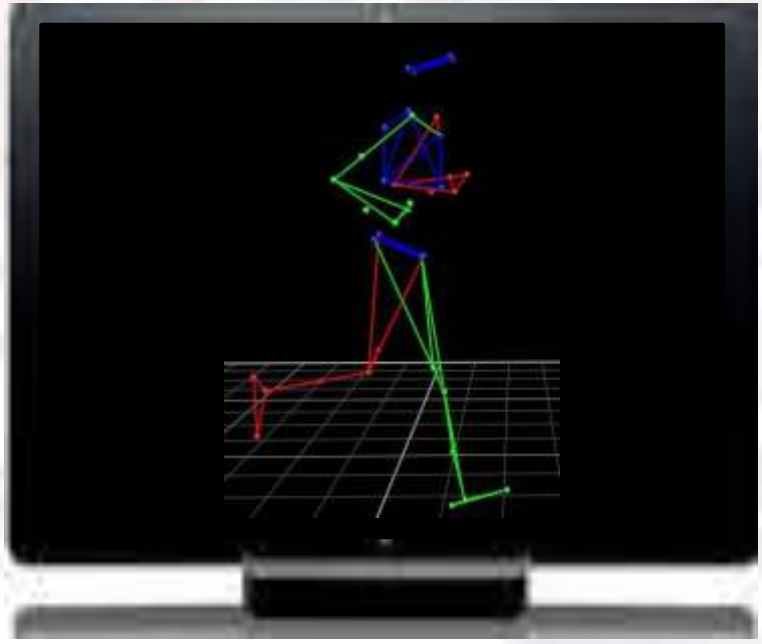
MATERIALS and METHODS

PARTICIPANTS

- 41 university students from the School of Exercise and Sport Sciences of Verona, (22 males and 19 females) were recruited for the experiment.

The experiment took place in two different sessions: a diagnosis session and a practice session.

- Field track 60m sprint test: to select the participants and to diagnose the technical errors;
- Treadmill (H/P COSMOS SATURN 300/100N) was used for the practice session;
- An eight-camera Vicon motion analysis system was used for kinematic measurements during treadmill-running;
- Data analysis was executed with a custom program written in Matlab.



PROCEDURE

DIAGNOSIS SESSION

The diagnosis session took place on the field track through a qualitative analysis.
The participants were instructed to perform a 60 m sprint at their maximum velocity.

This session aimed:

1. To select the participants on the basis of their vertical projection of the centre of mass (COM) behind the base of support at touchdown.

- Only participants with this incorrect projection of the COM were selected for the experiment (n = 22), and formed the study population. The selected participants were randomly assigned to one of two training conditions: 'main error' correction and 'secondary error' correction.

2. To identify the technical errors that may have lead to this backward projection of the COM.

- For a detailed assessment of technical errors the help of high-speed video at 100 Hz was used.

DIAGNOSIS

In the qualitative analysis the diagnoses of errors is a critical stage

1. To recognise difference between observed and desired movement
2. To identify the strengths and the weaknesses
3. To identify the technical errors

*How can we decide which are the **causes of errors and their effects?***

Some rationales could be selected (Bartlett, 2007):

- To determine the performance criteria;
- To break the skill into parts;
- To determine the mechanical factors affecting performance;
- To consider the risk of injury;
- To identify the critical features

To identify the critical features of the movement from a biomechanical point view

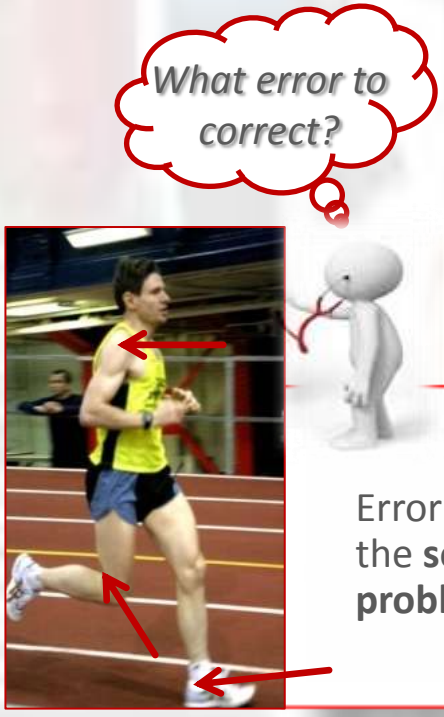
- The COM projection at touchdown:
  - ✓the distance between the first contact and the vertical projection of the COM must be as small as possible (Skof & Stuhec 2004).

- The foot strike pattern at touchdown:
  - ✓the touchdown should be made by the forefoot to allow the cushioning phase and the recovery of elastic energy, (Ardigò et al., 1995);
  - ✓the rear-foot strike runners had an overall injury rate twofold higher than forefoot strike runners (Daoud et al., 2012; Tam et al.,2014).

DIAGNOSIS

The most common errors observed among participants at touchdown were:

- the rear-foot strike
- a rearward shoulder position with respect to the base of support
- a rearward contralateral swing leg position with respect to the base of support.



Error which represents the **source of problems.**

THE MAIN ERROR

SECONDARY ERRORS

Errors which represent the **symptoms of problems,** they may be reflective of compensatory adjustments to achieve the final movement.

As the foot segment is important for cushioning phase and the recovery of elastic energy, it was hypothesized that the foot position at touchdown is more influential in the performance and risk of injury than the shoulder position or contralateral swing leg position.

- **The rear-foot strike was hypothesized as the 'main error'**
- **The shoulder position, behind the base of support, the 'secondary error'.**

PROCEDURE

PRACTICE SESSION

Each participant performed on the treadmill 10 trials of 10 seconds at their own selected running speed in the following sequence:

- one pre-training trial (T_0)
- 8 training-intervention trials
- one post-training trial (T_1)

'INTERVENTION'

1 'CONSTRAINED TRIAL'

The subject exaggerates the main error as much as possible:

ME Group

"touchdown with the heel as far back as possible"

SE Group

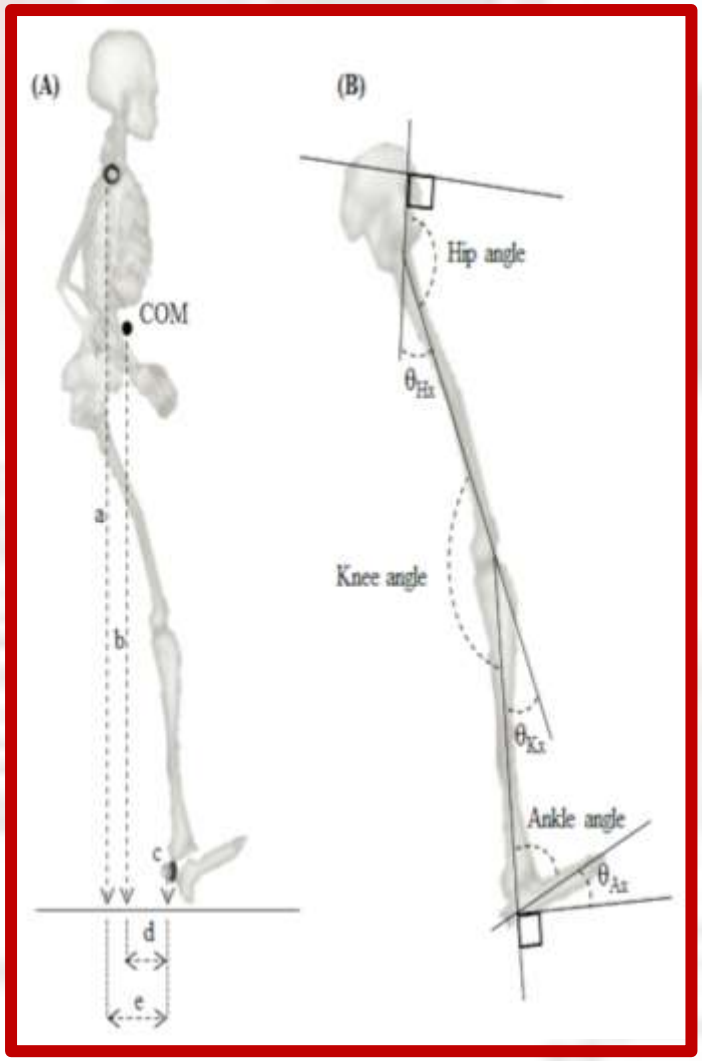
"touchdown keeping the shoulders as far back as possible"

2 'FREE TRIAL'

The athlete performs the movement freely without any constraints.

Steps 1 and 2 are repeated four times in an alternating sequence

DATA ANALYSIS

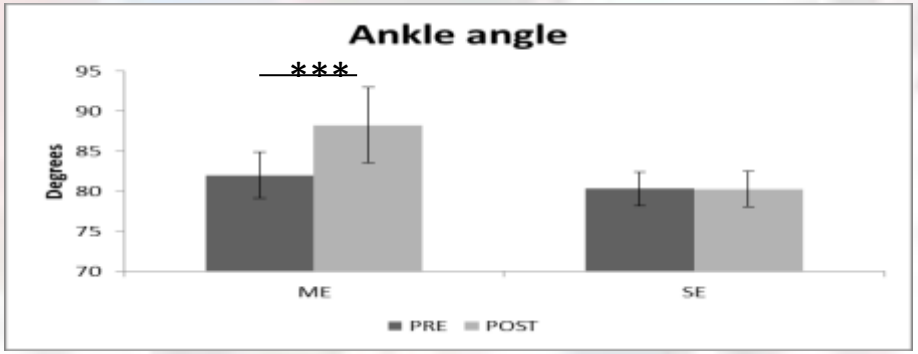


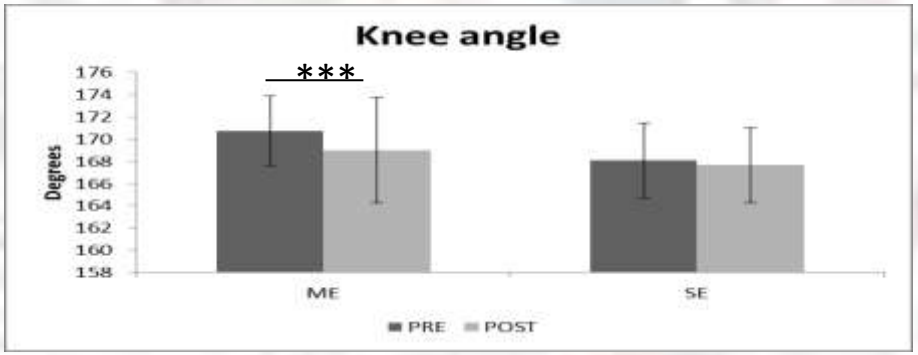
Kinematic parameters:

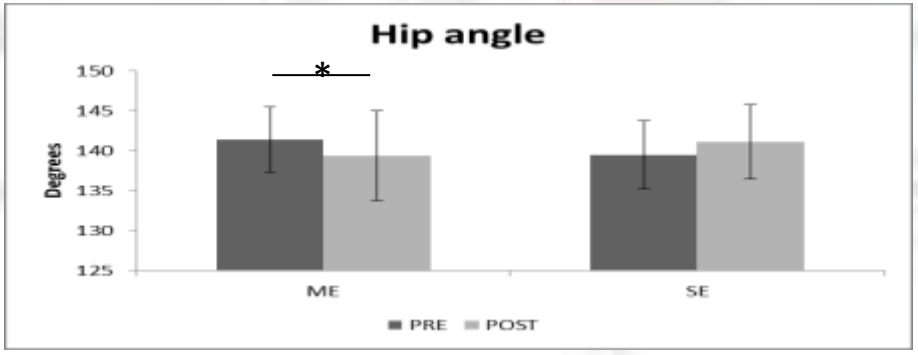
- Ankle, knee and hip angles (B).
- Horizontal distance between the COM and the heel (d).
- Horizontal distance between the shoulder and the heel (e).
- Toe and heel height with respect to the ground.

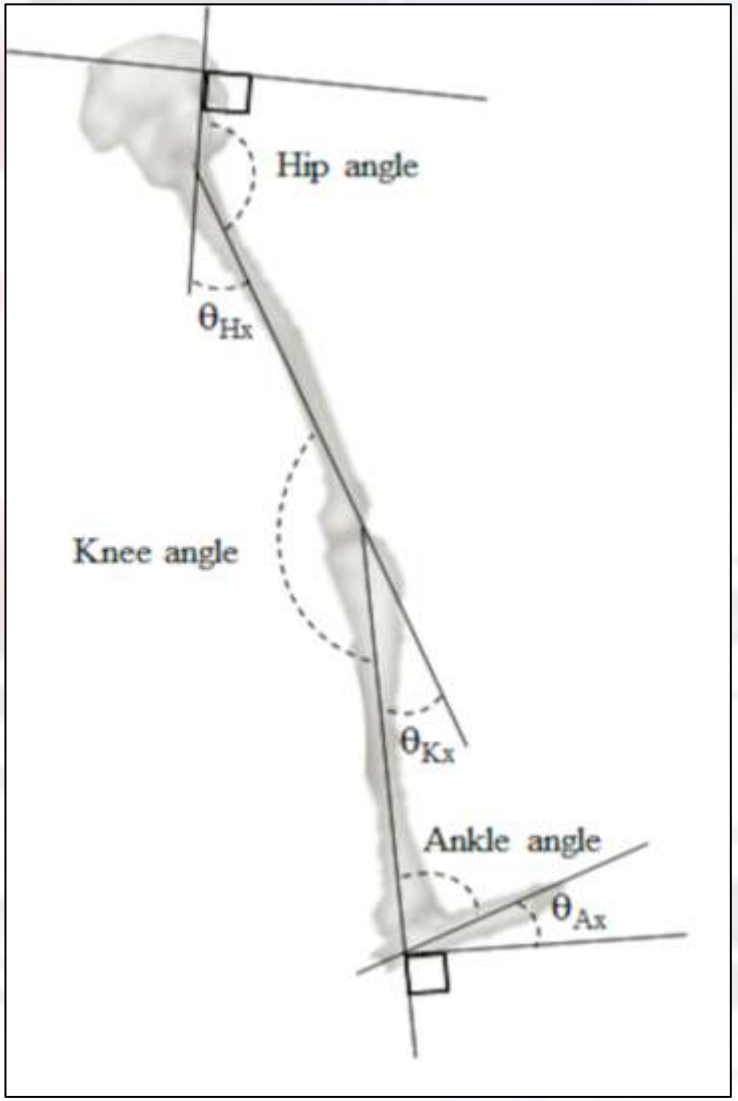
For statistical analysis the six gait cycles within the central 5 s of the total 10 s of the pre-training and post-training trials were considered.

RESULTS 1

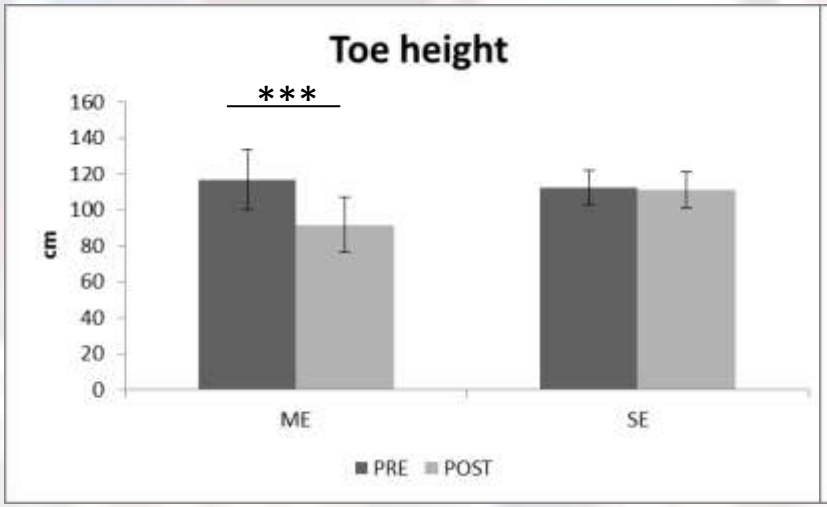

Ankle angle
***
95
90
85
80
75
70
Degrees
ME
SE
PRE
POST

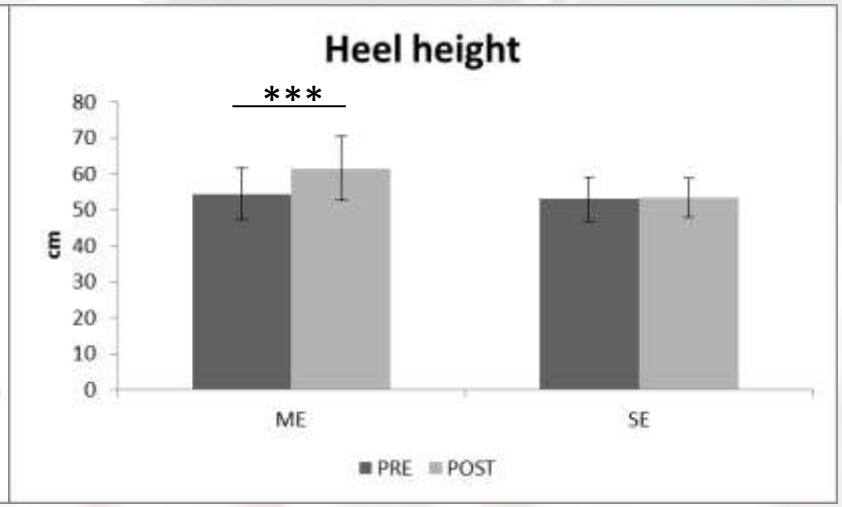

Knee angle
***
176
174
172
170
168
166
164
162
160
158
Degrees
ME
SE
PRE
POST

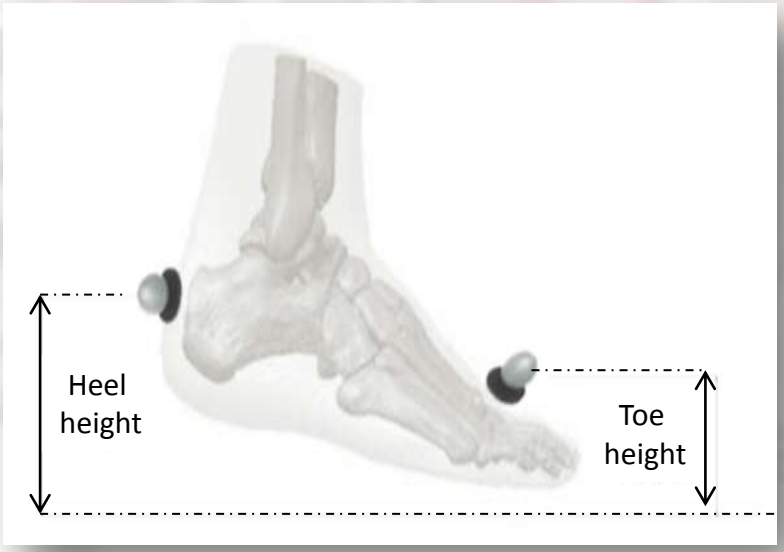

Hip angle
*
150
145
140
135
130
125
Degrees
ME
SE
PRE
POST


Hip angle
θHx
Knee angle
θKx
Ankle angle
θAx

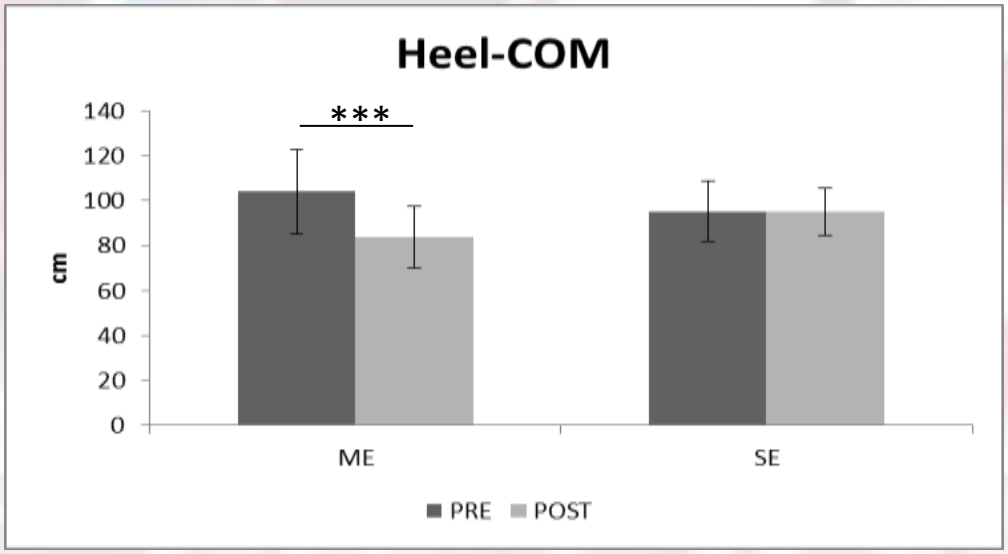
RESULTS 2

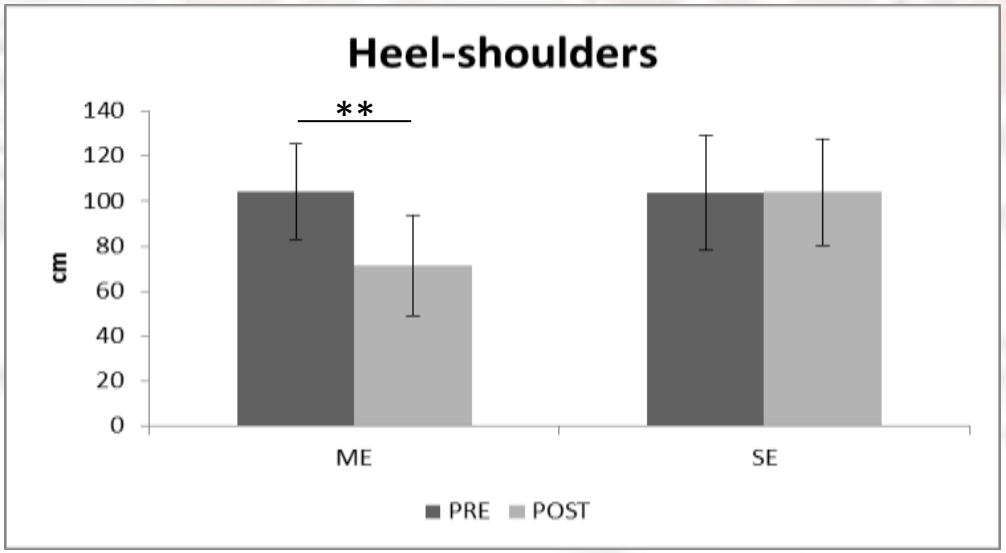

Toe height
***
160
140
120
100
80
60
40
20
0
cm
ME
SE
PRE
POST

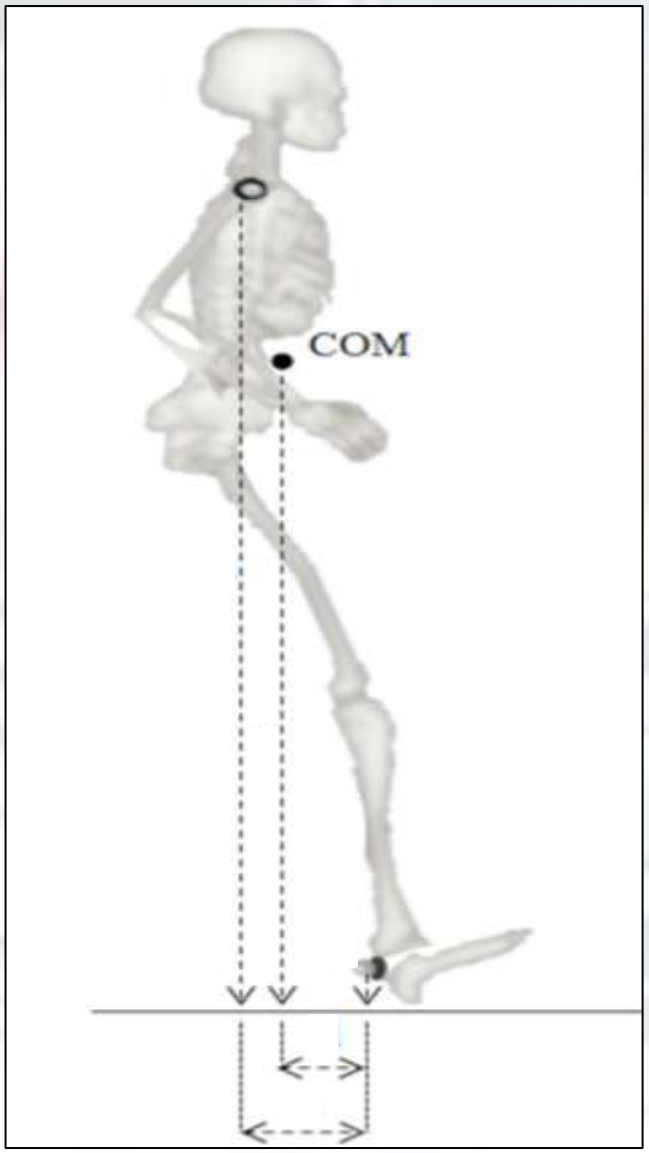

Heel height
***
80
70
60
50
40
30
20
10
0
cm
ME
SE
PRE
POST


Heel
height
Toe
height

RESULTS 3


Heel-COM
***
140
120
100
80
60
40
20
0
cm
ME
SE
PRE
POST


Heel-shoulders
**
140
120
100
80
60
40
20
0
cm
ME
SE
PRE
POST


COM

DISCUSSION 1

- The hypothesis that the main error has a greater influence on a movement patterns than a secondary error has been confirmed.

- The results support the idea that among the technical errors, **only one affects the performance most strongly**.

What are the reasons why the intervention on the secondary error did not have any effect?

- A possible explanation could come from research in neurophysiology. It was understood that during motor adaptation the nervous system constantly uses error information to improve future movements, however not all errors are relevant to the outcome of the action (Wei and Körding , 2009).

    - **The nervous system interprets cues in terms of their causes.**

- We may argue that a secondary error is not perceived by the nervous system as a task-relevant feature, so a corrective intervention of an error that is a symptom of the problem is not detected by the nervous system.

DISCUSSION 2

- Forced exaggeration of the error helps the learner to make useful comparisons between their usual movement and the amplified error movement.
- This mental comparison process between movements would be expected to yield a signal in which the amplitude of this signal depends on the degree to which the two representations differ, known as the 'mismatch' (Bernstein et al., 1995).
- It seems that this comparison process happened when the coach's intervention focused on the error that most strongly influences the dynamic balance of the body, and has the greatest effect on the performance outcome, i.e. the main error.
- Further research will be necessary to explore the impact of MAE on the learning of other sports, as well as the plastic adaptive changes in neural circuits which is at the heart of increased error detection capability in the learner.

MAE APPLICATION ON ALPINE SKI

- In competitive skiing, the skier aspires to carved turns with minimal lateral skidding and low frictional forces to achieve a fast run time.
- Alpine ski is characterized as a complex series of movements with multiple degrees of freedom, which requires a high level of coordination and temporal sequencing.

What are the key points when observing the movements of the skier

The main critical features of the movement from a biomechanical point view are:

✓COM trajectory
✓Ski trajectories
✓Load distribution between the outer and the inner ski

To break the turn into parts:
✓Initiation
✓COM direction change I
✓COM direction change II
✓Completion

QUALITATIVE ANALYSIS

Observation and diagnosis from a frontal plane

The coach identified a repeated and constant error during the turn: the inner ski is more strongly loaded than the outer ski.

QUALITATIVE ANALYSIS

Constrained trial: “error amplification”

The coach asked the athlete:

“to lift the outer ski at the beginning of the turn”.

“to move the load as much as possible onto the inner ski during the change direction I ”.

QUALITATIVE ANALYSIS

Free trial

Pre-corrective intervention trial

Post-corrective intervention trial

After one error amplification trial the athlete showed a better posture minimizing the lateral skidding and a better distribution of load on the inner and outer skis during the change direction I and II.

CONCLUSIONS

- In the future, it would be interesting to carry out studies in order to create guidelines for coaches, based on an understanding of the most important differences between biomechanical models and the observed movements.

- The creation of these models and classification of errors would bridge the gap between quantitative analysis of movement in controlled conditions and the qualitative analysis in the field by the coach.

- The application of biomechanics in the qualitative analysis of sport skills can also be improved by greater international cooperation in research on this topic.

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Thank you for your attention!

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