GROUND REACTION FORCE AND THE FORCE ON CENTER OF MASS

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INTRODUCTION: Force plate measurements pertain to standard investigations in biomechanics. Using force curves of drop jumps etc. The purpose is to analyze impulse, rise time or maximum of height. These forces are ground reaction forces, which are composed of the actions of the different parts of the human body. We usually imply a direct correlation to the force of Center of Mass (CM). But the human body is not rigid. We also need to take into account the case of dissipative forces.

METHOD: Investigating 60 hockey shots, we measured ground reaction forces of both legs and used synchronously three video cameras to record the motions of athletes. The calculation of CM acceleration produces an essential phase shift of the acceleration of the measured ground reaction forces (minus body weight). It lasted up to 0,25s. This difference requires an explanation, because it implies serious consequences for the interpretation of force plate measurements. Therefore, we cheeked the methods of investigation, but we found no error. Now, there are two sources of error: first, the model of CM we had found differences up to 8cm between measured CM on scales and calculated CM) and second, the spring and damping effects, on the limbs. We decided to test the second case. In order to get a first overlook we used a two mass model: the lower mass of 20kg weight and the upper mass of 50kg moving in a vertical straight line dependent of a modeled force F, which acts only between the lower mass and the ground. The masses are connected by an spring and damping element. Both masses fall down (drop jump), and the simulation starts at this moment, when the lower mass impinges on the ground. Wrench was not especially modeled. Velocities at the beginning may be wrongly chosen. According to the properties of spring and damping, at first masses swing downwards separately and, if force F gains influence, swing upwards once again. Thereby, F acts on the CM.

RESULTS: Shown below the results of three different modeled "drop jumps". From left to right: Week jump with equal velocities of both mass v1=v2=-2m/s; the same jump with higher velocity of lower mass, v1=-2,5m/s but v2=-2m/s; hard jump with v1=-2,5m/s and v2=-2m/s. It is clear that the resulting phase shifts in the case of week coefficients of spring and damping. Left peak in all figures belongs to the acceleration of the lower mass (representing ground reaction force), right peak belongs to the acceleration of the CM. But in case of more stiffness, the typical force peak occurs at the moment of contact with the ground (right figure).

DISCUSSION: There is no reason to assume that the ground reaction force in each case acts directly on the CM. We have to bear in mind the several physical properties of human body, for instance spring and damping elements for each joint. If one receives a greater phase shift between ground reaction force and force on CM, one must use a mathematical model to get reasonable interpretations of force curves. Further investigation must try to reveal, for which kind of (fast and strong) movements the described effect proves not to be negligible.