ONCE MORE ON THE BIOMECHANICAL PRINCIPLE OF THE INITIAL FORCE. THIS TIME IN CEREBRAL PALSY.

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The main purpose of the study was to evaluate the patterns of the developed ground reaction forces in the two – legged countermovement jumping, performed by persons affected by tetraparesis with ataxia, tetraparesis with athetosis, tetraparesis with spasticity, diplegia with spasticity, right and left hemiplegia and, finally, right and left hemiparesis. After twenty subjects jumped on the surface of a force plate analysis of the ground reaction force – time trend took place. The obtained results confirm the accomplishment of the biomechanical principle of the initial force as in the case of persons not affected by neurological disorders. Finally the calculated ratio between the breaking impulse and the acceleration impulse is very near to optimum values (.3 to .4).

KEY WORDS: biomechanics, countermovement jump, cerebral palsy

INTRODUCTION: Since N. Bernstein had stressed the influence of external, gravitational and inertial forces on movement kinematics, biomechanics approach is aiming to deduce relations between the mechanical goal of multi-joint movements, the movement kinematics and the underlying driving forces. Much later Hochmuth defined sport technique as "*a biomechanical resolution A of a specific motor problem which can also be B, C, D, etc., on*

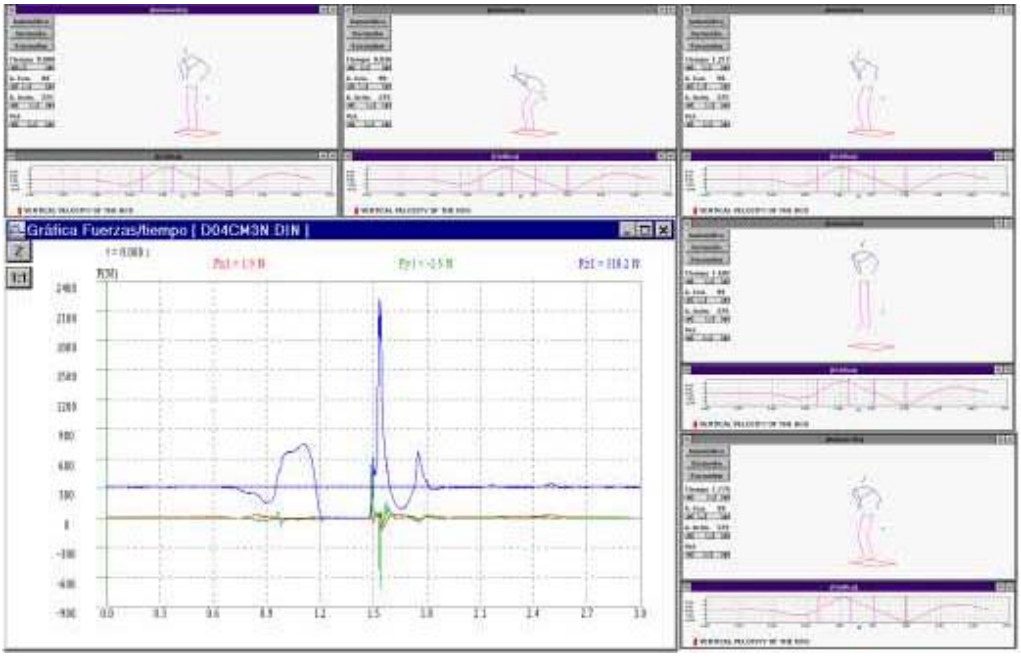

Figure 1 - Simulation of the countermovement two - legged vertical jump and representation of the components of the ground reaction force.

the basis of the performer's biological system conditions and characteristics, the mechanical conditions of the environment, the sport rules and tactical considerations", and suggested the biomechanical principles as a theoretical field of generalised criteria that allow for evaluating the level of sport technique quality. Even if the application of the Biomechanical Principle do not resolve the totality of the problems in elite sports, they are very useful tools for analysis and evaluation of the structure of the motor patterns. According to the *principle of initial force,* in the countermovement two - legged vertical jump, where a bending - stretching cycle (stretching – shortening cycle) is taking place, with immediate reversal of movement, at the very beginning of the stretching is present a positive initial force (lowest position of the centre of gravity) due to the breaking of the bending movement (Fig. 1).

This initial level of force enables an increased acceleration impulse, if the ratio between the breaking impulse and the acceleration impulse has an optimum value between .3 and .4, yielding an increased take off velocity. The mentioned values of the relation between the breaking and acceleration impulses have been confirmed by dynamometric data and imply a controlled transition from the initial countermovement to the take off. On the other hand cerebral palsy (CP) as neurological disorder is characterised by lose of the selective control of muscles, and the emergence of spasticity and primitive patterns of contraction, inducing longstanding controversies in the classification of athletes with disabilities for competition. The purpose of the present study, which is part of a wider project orientated to analyse the motor capabilities of physically disabled, is to investigate the mode of action of the biokinematic chain of the lower limbs in the two - legged countermovement vertical jump for persons affected by cerebral palsy. In addition special attention is paying to concerning the accomplishment of the principle of initial force. Finally, it is worth to stress that all methodological considerations, correctly established by Hatze (1998), concerning the validity and reliability of the countermovement jump, as a test procedure for evaluation of muscular power of the lower limbs biokinematic chain, are not critical questions for this study.

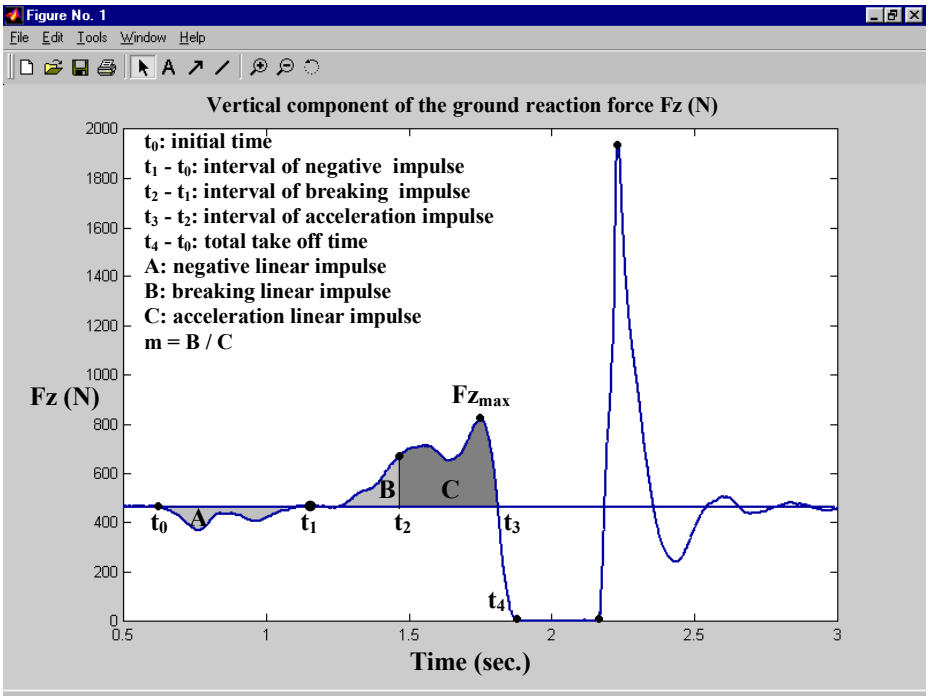

Figure 2 - Definition of the study parameters.

METHODS: Twenty subjects affected by different symptoms of cerebral palsy like tetraparesis with ataxia, tetraparesis with athetosis, tetraparesis with spasticity, diplegia with spasticity, right and left hemiplegia, right and left hemiparesis, asked by their instructors to perform two – legged countermovement vertical jumps, jumping as high as possible, keeping their hands on the hips and performed with no other constraints than the anatomical. Ground reaction forces were registered by an origin - calibrated strain-gauge force plate (DINASCAN 600M) at a sampling rate of 500 Hz. The calculated errors with respect to the measurement of the components of the ground reaction force are below 2%. The processing of the information referred to the vertical component of the ground reaction force evolution during the two-legged countermovement jump yielded the following study parameters:
the total take off time, the time intervals of the linear force impulses, the instant of maximum force, the maximum force, the slope of the best fit line to the positive force– time trend, the take off velocity, the mean value of the normalised to the weight force in the interval of the acceleration impulse, the value of the three parts of the linear force impulse (negative impulse,

breaking impulse, acceleration impulse) and finally the ratio (m) between the breaking and acceleration impulses (Fig.2).

RESULTS AND DISCUSSION: The first consideration is that despite the wide variety of motor disorders and symptoms of the investigated subjects, namely, tetraparesis with ataxia, tetraparesis with athetosis, tetraparesis with spasticity, diplegia with spasticity, right and left hemiplegia, right and left hemiparesisthe, results confirm the accomplishment of the biomechanical principle of initial force.

Table 1 Statistics of the Study Parameters

	Mean	Standard Error	Standard Desviation	Variation Coefficient
$(t_4 - t_0)$(s)	0,69	0,048	0,215	0,31
$(t_1 - t_0)$(s)	0,31	0,025	0,111	0,36
$(t_2 - t_1)$(s)	0,15	0,014	0,063	0,43
$(t_3 - t_2)$(s)	0,07	0,013	0,058	0,80
$(t_{max} - t_0)$(s)	0,53	0,047	0,212	0,40
Fz_{max} (N)	1311,42	94,569	422,924	0,32
slope of best fit line to force – time curve	3625,46	512,968	2294,063	0,63
take off velocity (m/s)	1,82	0,096	0,428	0,24
C (N.s)/ weight (N)	4,64	0,230	1,029	0,22
A (N.s)	37,04	3,444	15,401	0,42
B (N.s)	37,04	3,444	15,401	0,42
C (N.s)	106,01	9,656	43,183	0,41
m (B/C)	0,35	0,015	0,067	0,19

where:

$(t_4 - t_0)$(s): total take off time.
$(t_1 - t_0)$(s): interval of negative impulse.
$(t_2 - t_1)$(s): interval of breaking impulse.
$(t_3 - t_2)$(s): interval of acceleration impulse.
$(t_{max} - t_0)$(s): instant of maximun force.
(Fz_{max}): maximun force value.
A: negative linear impulse.
B: breaking linear impulse.
C: acceleration linear impulse.
(m=B/C): ratio between breaking and acceleration impulses.

This is a very interesting finding given that muscles normally are unable to contract adequately at the appropriate times due to a loss of coordination, also the muscular contraction cannot be turned on or off rapidly taking commonly place a co-contraction of antagonists. Finally there are considerable variations between one patient and another in the way in which CP affects the positions and movements of the joints.

Descriptive statistics (Table 1.) allow for having a clear idea with respect to the evolution of the vertical component of the ground reaction force. However the variation coefficient indicates the expected lack of homogeneity for all variables but the total take off time (0.31), the values of the acceleration impulse referred to the weight (0.22) and the value of the ratio between the braking and acceleration impulses (0.19). Concerning this parameter the finding of a mean value of

(0.3535) for the twenty subjects with different symptoms of cerebral palsy confirms completely the principle of initial force.

CONCLUSION: This study provide relevant and objective information with respect to the two - legged countermovement vertical jump performed by persons affected by cerebral palsy and confirm that the principle of the initial force is taking place in the same way as in the case of persons no affected by neurological disorders.

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