7 - IMPACTS DURING LANDING IN DIFFERENT SPORTS

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Introduction

In different sports landings are the moments with the highest injury risk. The movement technique of the preparation phase before the first ground contact is important for the distribution and trajectory of the ground reaction force [1]. Landings with an adequate movement technique, especially concerning the angles of the knee and ankle at the moment of the first ground contact with lower angular velocities, reduce the injury risk significantly [2, 3]. High impacts of about 8 times body weight can be significantly reduced by voluntary movement control of the joint angles of the lower limbs [4].

The most important factors that define the impacts during landings are the mechanical properties of sport shoes and surfaces, velocity of landing, innervation patterns of the lower limb's muscles and kinematic movement pattern. The only variables which can be controlled voluntarily by the individual are the innervation pattern and kinematic movement characteristics [2].

One of the most important aims of Preventive Biomechanics is the analysis of mechanical load that characterizes specific sport movements and that result in higher injury risk especially during landings. Based on these information, strategies should be developed in order to minimize injury risk by the reduction of impacts. Therefore it is necessary to identify the impacts of landings of athletes in different sports and of non athletes and to correlate the impacts with kinematic variables of the landing technique.

The aim of the present study was:

a) Identification of the impacts during landings in volleyball, basketball, indoor soccer and of non athletes;

b) Determination of correlations between impacts and kinematic variables of the movement pattern during landing;

c) Compare kinematic characteristics of landings with low and high impacts

Materials and Methods

The subjects of this study were composed by four groups. Three of them were athletes of different sport games (professional volleyball players, junior basketball and junior indoor soccer players) and the fourth group was composed by college students who did not practice sports (table 1).

Table 1- Subjects of the study.

Group	Sports	N	Age (years) Mean ± sd	Body mass (Kg) Mean ± sd	Sex
VB	Volleyball	19	20,2 ± 2,9	84,6 ± 7,3	m
BB	Basketball	19	13,5 ± 0,5	64,3 ± 13,3	m
IS	Indoor Soccer	13	13,8 ± 0,6	57,3 ± 5,7	m
NA	Students	10	13,8 ± 0,6	43,3 ± 10,1	m, f

Analysis of dynamic and kinematic variables

The subjects performed three countermovement jumps with maximal effort on a force platform (AMTI OR6-7) where the ground reaction forces were registered at a frequency of 1 KHz. The subjects did not receive any information about landing techniques so that every individual performed his own landing technique. The falling height of each jump was calculated by the determination of the jumping impulse. That means that the falling height was determined by the individual's jumping capacity, so that every subject landed from a falling height equal to their maximal jump height. The force-time characteristics were registered and analyzed by the software DasyLab 4.0. The peak of the impact force normalized in relation to body weight and the time from the beginning of the ground contact to peak of impact were determined.

For the group of indoor soccer players kinematic variables of the landing technique (angles and angular velocities of the ankle, leg, and hip) were determined in the saggital and frontal plane by two high speed video cameras operating at 125 Hz (ACAM G 500, Redlake Imaging Corporation). 60 frames before and after the first ground contact were digitized by the use of SIMI Motion 6.0 software. The raw data were filtered by a 10 Hz digital low pass filter.

Statistics

In order to compare the the impacts of different groups of athletes and college students a variance analysis (ANOVA one-way) was applied. The kinematic variables were correlated with the dynamic variables by the calculation of the Spearman correlation and the kinematic variables of high and low impact landings were compared by the Wilcoxon test. The professional volleyball players' jumps were divided into the low and high impact group which contained the jumps with the highest and lowest impacts of each individual (table 2). All statistical procedures were calculated by SPSS 11.0.

Table 2- Characteristics of High and Low Impact groups.

	High Impacts	Low Impacts	N	p
Impact [N/BW]	9,31 ± 1,57	6,32 ± 1,47	19	0,003

BW = Body Weight

Results

Table 3 shows the mean values and standard deviation of the maximal (MAXIMP) and mean impacts (MEDIMP) for the different groups.

Table 3- Mean and standard deviation of maximal (MAXIMP) and mean impacts (MEANIMP).

Sports	MAXIMP [Body Weight]	MEANIMP [Body Weight]
VB	5.57 ± 1.36	5.11 ± 1.17
BB	6.43 ± 1.50	5.40 ± 1.40
IS	8.68 ± 1.74	7.96 ± 1.56
NA	6.58 ± 1.66	5.55 ± 1.26

In relation to the mean and maximal impacts, the variance analysis *one-way* shows that there are no significant differences between the groups VB, BB and NA. Indoor soccer players however have significant higher impacts (mean impacts as well as maximal impacts) than the three other groups.

The results of the descriptive statistics show that 40% of the mean impacts of the professional volleyball players and more than 50% those of the junior basketball players as well as college students exceed 5 x Body Weight. In one of three landings, the maximal impact exceeded 5 x Body Weight of 65% of the professional volleyball players and 85% of the junior basketball players and college students.

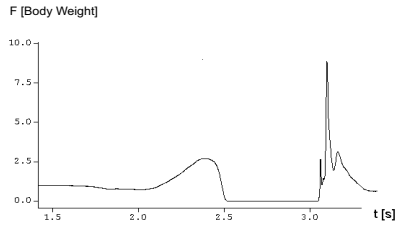

FIGURE 1: Impact exceeding 8 x Body Weight (professional volleyball player)

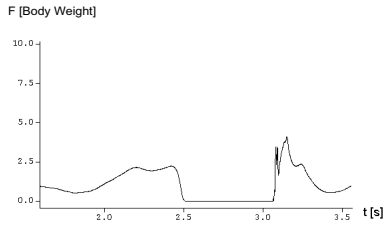

FIGURE 2: Impact less than 5 x Body Weight (professional volleyball player)

Table 4 shows the correlation of kinematic variables with the impacts for the Low and High Impact landings. The time from 1st ground contact to impact and to the lowest CG height correlate significantly with the impacts of high impact landings, whereas the angles of the ankle at 1st ground contact and of the knee at impact correlate significantly with the impacts of low impact landings.

Table 4- Correlation between kinematic variables and impacts at high (HI) and low impact (LI) landings.

nematic variables	HI	LI
ngle of the ankle at 1st ground contact	- 0,473	- 0,636*
nee angle at impact	0,309	0,727**
me from 1st ground contact to impact	- 0,706**	- 0,518
me from 1st ground contact to lowest CG position	- 0,668*	- 0,187

* significant at p <0,05; ** significant at p <0,01

Comparing the kinematic variables of high and low impact landings, the results of table 5 show that there are significant differences of low and high impact landings concerning the angle of the ankle at 1st ground contact and the time of the impact after the 1st ground contact.

Table 5- Significant differences between high and low impact landings.

Variables	High Impacts	Low Impacts	p
Ankle angle at 1st ground contact	121,3º ± 10,8º	127,5º ± 3,6º	0,050
Time to impact	0,048 s ± 0,01s	0,066 s ± 0,01 s	0,013

Discussion and Conclusion

The findings about the ankle angle at the first ground contact corrobotare the results of Valiant & Cavanagh that lower impacts are associated with higher plantar flexion. The results of Gross & Nelson [5] also emphasize the importance of the ankle for impact reduction. Stacoff et al [2] found a significant correlation between the knee angle (at the moment of impact) and the impact which was only observed for the low impact landings in the present study. The results of Gross & Nelson [5] and Valiant & Cavanagh [3] that a longer period between the first ground contact and the impact will reduce the impact could also be confirmed by this study. However, a significant correlation between the angular velocity of the knee and impact as it was found by Stacoff et al. [2] could not be confirmed, probably because of the relative small sample of this study.

Based on this and former studies it can be concluded that greater plantar flexion leads to a longer time between first ground contact and lowest CG position which results in a later incidence and lower impacts.

Physical educators and teachers should be aware of the incidence of high impacts during landings of college students, which is higher than for professional volleyball players. Since sport grounds of Brazilian colleges usually are not adequate for impact reduction and students often do not use adequate shoe ware, an adequate movement technique is the only way to reduce impacts. This requires a special attention to dropping heights and landing technique.

Landing technique should be investigated in different situations (fatigue, different surfaces and shoes) not only based on time discrete variables, but also by analysis of time series as suggested by Schöllhorn [6] and Schöllhorn et al. [7]. This approach permits the identification of individuality and fluctuations of motor learning and the adaptation of the motor system to different situations.

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IMPACTS DURING LANDING IN DIFFERENT SPORTS

Abstract
The aim of this study was to identify the impacts during landings and to correlate these impacts with kinematics variables referred to the movement technique. The study was performed with three groups of athletes (volleyball - VB, basketball - BB and indoor soccer - FS) and a group of non-athletes (NA). The volunteers performed maximal Countermovement Jumps on a force plate. Beyond the dynamic analysis the indoor soccer group was submitted to a kinematic analysis. No significant differences between the groups VB, BB and NA concerning the impacts magnitude could be found. 40% of the volleyball players and 50% of the basketball players and non-athletes have mean impacts higher than 5 x body weight. This indicates an inadequate landing strategy. The group FS produced significantly higher impacts than the other groups. The time from the first contact to the highest impact was significantly different between the landings with low impacts (0,066 ± 0,01ms) and landings with high impacts (0,048 ± 0,01ms), as well as the angle of the ankle at the first contact (127,5º ± 3,6º) and (121,3º ± 10,8) in landings with low and high impacts, respectively. It can be concluded that an adequate movement technique can reduce maximal impacts and injury risk.
Key words: impacts, movement technique, injuries

ANALYSE d'IMPACTS PENDANT des ATÉRRISSAGES d'ATHLÈTES de DIFFÉRENTES MODALITÉS ESPORTIVAS

Resume
l'objectif de cette étude a été identifier à la grandeur des impacts pendant des atérrissages de différents groupes des athlètes et des athlètes et ne pas corréler tels impacts (force de réaction verticale) avec des variables cinématiques afférentes à la technique de mouvement (angle et vitesse angulaire). L'étude il a été réalisé avec trois groupes d'athlètes (des joueurs professionnels de volley-ball - VB, joueurs de basket-ball de la catégorie Junior - BB et joueurs de Futsal de la catégorie Junior - FS) et un groupe non d'athlètes - DANS. Les volontaires ont exécuté trois sauts maxima en utilisant la technique avec contremouvement sur une plate-forme de force. Outre l'analyse dynamique, le groupe de Futsal aussi a été soumis à une analyse cinématique tridimensionnelle à travers deux caméras de haute vitesse (125 Hz). Il n'a pas été trouvée différence significative entre les groupes VB, BB e NA combien à l'impact maximum et à la moyenne d'impacts des trois sauts réalisés. Statistique descriptive a montré que 40% des athlètes professionnels et plus de 50% des athlètes de basket-ball et des athlètes n'a pas présenté d'impacts moyens supérieurs à la valeur de 5 x poids corporel, en indiquant une technique inadéquate d'atérrissage. Les athlètes de FS ont présenté des impacts significativement plus grands que les athlètes des autres modalités. L'analyse cinématique a indiqué que le temps depuis premier contact avec le sol jusqu'au bourgeonnement de plus le plus grand sommet d'impact a différé statistiquement entre les groupes abaisse impact (0,066 ± 0,01ms) et sommet impact (0.048 ± 0,01ms), ainsi que la valeur de l'angle dans le joint de la cheville au moment du premier contact avec le sol (127,5º ± 3,6º) et (121,3º ± 10,8º) dans atérrissages avec des basses et des sommets impacts, respectivement. Ces résultats indiquent l'importance de technique de mouvement dans l'humectation, malgré ne pas être seul facteur qui influence dans la génération de hauts chargements pendant des atérrissages.
Mots clés: atérrissages, impacts, technique de mouvement

ANÁLISIS DE IMPACTOS DURANTE ATERRIZAJES DEL ATLETA DE DIVERSAS MODALIDADES ESPORTIVAS

Extracto
El objetivo de este estudio era identificar a la magnitud de los impactos durante aterrizajes de diversos grupos del atleta y del atleta y no correlacionar tales impactos (fuerza de la reacción vertical) con referir las variables cinemática a la técnica del movimiento (ángulo y velocidad angular). El estudio al grupo no del atleta fue llevado a través con tres grupos del atleta (jugadores profesionales del voleibol - VB, jugadores del baloncesto de la categoría menor - BB y jugadores de Futsal de la categoría menor - FS) y - adentro. Los voluntarios habían ejecutado tres saltos máximos que utilizaban la técnica con el countermovement en una plataforma de la fuerza. Más allá del análisis dinámico, el grupo de Futsal también fue sometido a una cinemática tridimensional del análisis a través de dos cámaras fotográficas de la velocidad (125 hertzios). La diferencia significativa entre los grupos VB, BB y en cuánto al impacto máximo y al promedio de los impactos de los tres llevó con saltos no fue encontrada. Estadística descriptiva demostró que el 40% de atletas profesionales y el 50% de los atletas del baloncesto y del

atleta tenían más que no actuales impactos medios superiores al valor 5 del peso corporal de x, indicando una técnica inadecuada del aterrizaje. Los atletas del FS habían presentado a impactos perceptiblemente más grandes esos los atletas de las otras modalidades. La cinemática del análisis indicó que el tiempo desde el primer contacto con la tierra hasta que diferenció el brote del pico más grande del impacto estatisticamente incorpora el impacto bajo de los grupos (0.066 ± 0,01ms) y el alto impacto (0.048 ± 0,01ms), tan bien como el valor del ángulo en el empalme del tobillo en el momento del primer contacto con la tierra (127,5º ± 3,6º) e (121,3º ± 10,8º) en aterrizajes con los bajos y los altos impactos, respectivamente. Estos resultados indican la importancia de la técnica del movimiento en humedecer, aunque a no ser el único factor que influencian en el colmo de la generación de la carga durante aterrizajes.

Palabras clave: aterrizajes, impactos, técnica del movimiento

ANÁLISE DE IMPACTOS DURANTE ATERRISSAGENS DE ATLETAS DE DIFERENTES MODALIDADES ESPORTIVAS

Resumo

O objetivo deste estudo foi identificar a magnitude dos impactos durante aterrissagens de diferentes grupos de atletas e não atletas e correlacionar tais impactos (força de reação vertical) com variáveis cinemáticas referentes à técnica de movimento (ângulo e velocidade angular). O estudo foi realizado com três grupos de atletas (jogadores profissionais de voleibol - VB, jogadores de basquetebol da categoria Junior - BB e jogadores de Futsal da categoria Junior - FS) e um grupo de não atletas - NA. Os voluntários executaram três saltos máximos utilizando a técnica com contramovimento sobre uma plataforma de força. Além da análise dinâmica, o grupo de Futsal também foi submetido a uma análise cinemática tridimensional através de duas câmeras de alta velocidade (125 Hz). Não foi encontrada diferença significativa entre os grupos VB, BB e NA quanto ao impacto máximo e a média de impactos dos três saltos realizados. Estatística descritiva mostrou que 40% dos atletas profissionais e mais de 50% dos atletas de basquetebol e não atletas apresentaram impactos médios superiores ao valor de 5 x peso corporal, indicando uma técnica inadequada de aterrissagem. Os atletas de FS apresentaram impactos significativamente maiores que os atletas das outras modalidades. A análise cinemática indicou que o tempo desde o primeiro contato com o solo até o surgimento do maior pico de impacto diferiu estatisticamente entre os grupos baixo impacto (0.066 ± 0,01ms) e alto impacto (0,048 ± 0,01ms), assim como o valor do ângulo na articulação do tornozelo no momento do primeiro contato com o solo (127,5º ± 3,6º) e (121,3º ± 10,8º) em aterrissagens com baixos e altos impactos, respectivamente. Estes resultados indicam a importância de técnica de movimento no amortecimento, apesar de não ser o único fator que influencia na geração de altas cargas durante aterrissagens.

Palavras chaves: aterrissagens, impactos, técnica de movimento.