LANDING IN GYMNASTICS

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INTRODUCTION

In present-day gymnastics, stable landing always makes the athletes' skillful performance even better and therefore has won worldwide emphasis. In her research paper, the author, who has been researching in this field for many years, presents a detailed analysis of ten athletes' landing movements, and finds a reliable and effective way of improving the quality of movement but decreasing the possibilities of injury.

SUBJECTS AND METHODS

Landing movements of ten famous athletes in gymnastics in China were chosen as subjects.

The author, by means of high-speed photography and photoanalysis, made a full-scale comparative study of the 9 major parameters out of 22 which jointly determines the quality of landing, based on quality pre-landing movements. They were the length and the width of the foot placement, the horizontal and the vertical speeds of the center of gravity movement, the touchdown angle, the buffering and braking angle, the hip angle, the knee angle and the ankle angle. Seven stable and seven unstable landing were analyzed (Table 1 and Table 2).

Table 2.
Average range of the angles of hips, knees and ankles during buffering

	At Touchdown						End of Buffering			Ranges of Angle			CM	T
	V	V_y	*a*	H	K	A	H	K	A	H	K	A	(m)	(s)
S	2.62	5.01	68.6	156	160	92	103	98	66.1	53	62	25.9	0.16	0.091
U	2.67	5.13	76.6	148	166	103	102	103	80.1	16	63	22.9	0.14	0.08
M	2.65	5.07	72.6	152	163	97.5	102.5	100.5	73.1	49.5	62.5	24.4	0.15	0.086

Notes:

a- the landing (touchdown) angle (deg.)
V_x - horizontal CM velocity (m/s)
V_y- vertical CM velocity (m/s)
H.- Hip angle
A.- Ankle angle
CM.- Change of location of CM
S.- Stable landing (7 cases)
U.- Unstable landing (7 cases)
M.- Mean (14 cases totally)
K.- Knee angle
T. - Total time used

RESULTS AND ANALYSIS

A. Technically well executed movements before landing determines the quality of landing (touchdown).

Technically well-executed movements before landing usually feature high flight, proper movements, elegance and gracefulness. The extended position of the joints at touchdown provide the subject with the option of using a large range of joint motion during the landing phase with sufficient vertical and horizontal rotations. Consequently, the anticipated balance of the subject during and at the landing (touchdown) phase is achieved. Otherwise, low flight always provides insufficient rotations, narrowing the possibilities of balance during and at the phase of landing. As a result, the subject is forced, either by the moment of the inertia or by the moment of gravity, to make a second adjustment of landing, a technical infraction as judged by the rules.

B. The mean landing (touchdown) angle should be fixed.

The landing (touchdown) angle is an angle formed by the line between the center of mass (CM) to the toe and the horizontal at touchdown. (See La in Figure 1)

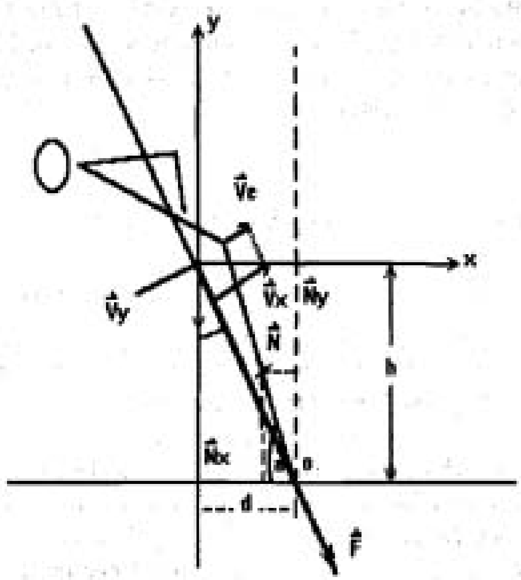

Figure 1. Landing inback somersault dismount

This research shows that in each landing process, 22 parameters (Table 1) work together, among which the length and the width of the foot placement, the vertical and the horizontal **CM** velocities are four relatively unchanging variables, while the landing (touchdown) angle, the braking and buffering angle, the angles of hips, knees and ankles are more varying, subject to variations during different movements of landing. The landing (touchdown) angle is, above all, of first priority in ensuring the stability of landing (touchdown).

According to the theories of mechanics, the process of landing is a process of counteraction between the moment of the inertia and the moment of gravity, subject to the landing angle in order to achieve balance. (Figure 1)

If the horizontal **CM** velocity at touchdown is very high, with sharp landing angle, then the moment of the inertia is very large, but the moment of gravity very small. In this case, the moment of gravity is too small to cancel out the moment of the inertia, and a technical infraction of **CM** deviation from its balance point appears.

On the contrary, if the horizontal **CM** velocity is slow, very small, and the moment of the inertia small, too, then the moment of gravity is so strong that the subject may fall instead of landing stably on the floor.

Only when the moment of gravity and the moment of the inertia cancel out each other and the **CM** falls on the 80-90% area of the valid support zone, will the subject stick on the floor at touchdown.

It has been proved that when the subject is training a certain kind of dismounts, the most appropriate landing angle can be found and relatively fixed. For instance, the mean landing angle of the subject's vault with turn around the horizontal axis is 69∞, when the horizontal **CM** velocity is 2.76m/s. During training, all 22 parameters should be measured and analyzed, figuring out the mean landing angle, in order to find out the reasons for failure or technical infractions in landing.

C. The knee angle is of first priority in buffering.

Buffering is the process of reducing the effect of an impact when landing. Research shows that the mean vertical **CM** velocity of women's vault is 5.07m/s. The correct techniques of buffering should be applied in counteracting the great reacting farce from the ground in landing, about 10 times the weight of the subject.

Table 2 shows the average range of the knee angle, 62.5∞, is the biggest among the knee angle, the hip angle and the ankle angle during and at the end of buffering. Therefore, the **knee** joint is the main buffering function joint, and special training on knee joint muscles and ligament should be stressed.

Table 2 also shows the stable landing (touchdown) requires longer time for buffering, longer distance of CM falling and larger range of knee angle extension.

The function of buffering is mainly fulfilled by contracting or extending the angles of hips, knees and ankles, adjusting the relative location of the CM to the support zone, principally falling to the valid area of it, so that balance is achieved. The location of the CM largely affects the moment of the inertia relative to the support point, and the angles of joints are determined by the location, the velocity, the landing angle and the velocity of rotation of the CM then and there. In Figure 1, the instantaneous horizontal velocity of the CM of women's dismounts from vaults ranges from 1.84 to 3.60m/s and landing angle 68.6∞. The higher instantaneous velocity at touch down, the larger range of joints contraction or extension, and so the easier for a stable landing.

In a word, the technically well executed movements of buffering at landing is of top priority in controlling the movements of landing, which reduces injuries but enhances the stability of landing.

CONCLUSION AND SUGGESTIONS

A. Technically well executed flying movements before landing phase with high flight provide larger landing angle but lower horizontal velocity of the CM, which makes it easier to land stably and deserves more stress and attention in training and coaching.

B. The faster the velocity of rotations in flight, the earlier the body should be extended for slowing down the velocity. The directions of tho rotation in flight determine the location of support point (toes). On the contrary, the slower the velocity of rotations, the farther the location of the support point falls behind the projection point of the CM. For instance, the support point falls ahead of the projection line of the CM in vault back somersault off.

C. The subject should fly with body extended, chest in, hip angle a little narrowed, legs straight and toes tightly stretched, so that the functions of buffering is well executed by all relevant parts. The earlier the body is extended in flight phase, the easier to figure out the correct direction and proper location. Also the earlier to see the floor, the better balance functions by the muscles at touchdown.

D. Landing movements without buffering, like stiffly extended or tucked