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Letter to Editor

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Skin Movement Rules Relative to Joint Motions

Tsutomu Fukui*, **Yuko Otake and Takashi Kondo**

Health Care Science, Graduate School, Bunkyo Gakuin University, Tokyo, Japan

***Corresponding Author**: Tsutomu Fukui, Health Care Science, Graduate School, Bunkyo Gakuin University, Tokyo, Japan, Tel: +81-3-3814-1661; E-mail: fukui@bgu.ac.jp

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It has been observed for a long period that in analytical research of 3-D motion, the location of markers placed on the skin does not coincide with the location of underlying bones. This is called a skin movement artifact (SMA) or soft tissue artifact. SMAs have caused greater errors than instrumental errors [1]. As the difference between skeletal and external motions is large [2], skin marker-derived kinematics are not representative of the underlying bone motion [3]. Researchers have made extensive efforts to minimize SMAs; nevertheless, kinematic estimation errors are present, even if the best-performing pose estimator is used [4]. These findings showed that considerable sliding occurs between the skin and underlying bones during joint movement, particularly between the subcutaneous tissue and superficial fascia. The magnitude of SMAs depended on the body site. SMAs have been found to reach magnitudes greater than 30 mm on the thigh and up to 15 mm on the shank, according to a systematic review [5]. Additionally, STA has a movement feature. SMAs are associated with unison movement of the marker set, suggesting that a large amount of kinematic noise is produced by the synchronous "shifting" marker sets [6]. The results of recent studies suggest the presence of linear SMAs, with synchronous shifting of the marker set and correlation with joint rotation.

We thought these linear SMAs were definitely the sliding of skin over bones. Simultaneously, we were interested in the skin motion of the contralateral side as a system of continuum. In the standing pelvic sway motion, the front skin of the thigh was transferred upward while the back skin was transferred downward during pelvic anterior sway. Opposite skin movements were observed during posterior pelvic sway. Similarly, the lateral skin was transferred upward and the medial skin was transferred downward during lateral pelvic sway i.e. hip adduction. The motion is vice versa during medial pelvic sway. In this way, skin of the contralateral side moves to the opposite direction [7].

When applying the shearing force to skin, we observed that skin movement affected joint movement. Elastic taping is one of the best methods to apply the shearing force to skin. It could keep shearing force on the skin and in the falling direction of body hair. Instruction of orientation to the skin is crucial and is acquired by taping direction. If a shearing force is applied to coincide with natural skin movement, the joint movement will increase. Nevertheless, in the case of opposite shearing direction, the joint movement will decrease. We have found some physiological rules of skin movement that are mentioned below [8].

Rule 1: A joint movement is limited in the direction that makes deeper creases (folds). Also with stretched skin, movement is limited in the direction that makes more stretch.

Rule 2: When the tension is taken off the stretched skin, movement will increase. In addition, when loosened skin is stretched, movements toward skin loosening will increase.

Rule 3: The direction of skin sliding is coordinated with movement of the joint. When bones move toward each other, the skin existing on approaching side slides away from the joint and the skin existing on the opposite side slides in the direction of the joint. With rotation, skin slides in the same direction as the bone.

Rule 4: Skin slides over superficial fascial layers. Guiding skin to influence skin tension lines will change the 'alignment' of skin and the underlying structures thereby influencing movement.

Rule 5: With every body movement, some areas of skin are stretched and others are loosened.

According to physiological skin movement, we have developed some methods completely different from others.

(1) Principle of guiding skin creases: Guiding skin in the opposite direction, away from the skin creases will increase the movement while guiding it in the direction of the skin creases will limit the movement.

(2) Principle of guiding surface prominences: When a prominence is visible during skin movement, loosening the skin around the prominence will increase mobility. Stretching the skin around a prominence will limit movement.

(3) Principle of guiding skin tension lines during rotation: Guiding the skin in distal direction along the skin tension lines will increase the rotation while guiding it in proximal direction along the skin tension lines will limit rotation. The skin adjacent to the head and trunk's midline (medial and lateral sides) and bordering the long axis of the extremities will slide (anteriorly and posteriorly) in opposite directions. Guiding the skin in one direction will increase rotation while guiding it in the other direction will limit rotation.

(4) Principle of muscle facilitation and inhibition: Guiding skin from the muscle's insertion in the direction of the origin will facilitate muscle contraction whereas guiding skin from the muscle's origin in the direction of the insertion will inhibit muscle contraction.

In case of ankle sprain, the usual taping technique was executed to release the tension of the anterior talofibular (ATF) ligament. Guiding skin surface on the ATF ligament in the opposite direction, away from the ligament will increase ankle pronation and decrease the ligament tension load. This technique should be applied while using elastic tape in a state of stretched skin. In this way, joint motion could improve by elastic taping or directional manual rubbing. Elastic taping has been able to keep the skin stretched or released for hours. It may stimulate Ruffini's corpuscles, which are slow threshold mechanoreceptors, having slow adaptive properties. After applying elastic taping, we can

say that skin has the capability of knowing its location relative to the bone as a continuity system.

We expect that skin, as an ectodermal system will be useful in a variety of musculoskeletal diseases in the near future.

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