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The Effects of the New Training Concept 'Slidation' on Postural Control in Pediatric Cancer and Hematologic Patients

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Abstract

Postural control is deemed to be an essential ability to maintaining or regaining stability under sports-specific aspects as well as in daily life under health-related aspects. Especially in cancer patients stability or balance oftentimes get lost under the influence of the disease and/ or the treatment which is healing on the one hand but can be severely impairing on the other hand.

This article will outline a one-year-study with four weeks interventions using a novel fascial training concept named 'Slidation' applied to a group of pediatric cancer patients (n=25) compared to controls (n=32). The results showed significant improvements for postural control measured by a Posturomed device with a 2-dimensional sensor attached. The results suggest the conclusion that 'Slidation' might be a useful additional training tool in a rehabilitation setting.

Keywords: *Stability, Balance, Slidation, cancer, fascial training, Pediatrics, Pediatric Oncology.*

Introduction

Cancer prevalence in children account for between 50 and 200 per million children across the world, representing between 0.5% and 4.6% of all cancers (1), whereas 8.8 million deaths were recorded in 2015 in total (2). Acute lymphoblastic leukemia (ALL) is the most frequent entity in childhood cancer (3-6). The physical side effects manifest in reduced aerobic capacity (7), neuromuscular deficits, as well as sensory and motor impairments, often related to deficits in lower extremity muscle strength and balance (8, 9). Thus these balance impairments apply to many patients in total and can lead to falls or unstableness which in turn can possibly lead to other subsequent problems.

Until the 1980's, physical activity was considered to be contra-productive in cancer treatment and resting was the most common medical advice. Influenced by the seminal study of Schüle (10) and based on a number of more recent clinical studies this view has changed and today physical activity and sports are widely accepted to provide positive effects in very different ways on cancer, including psycho-social, physical, immunological aspects and their interactions (11-17). Most studies on the effects of physical activity on cancer have been conducted on adults. Much less research has been done in pediatric cancer patients (18).

A decrease of balance ability is assumed to be one side effect of childhood cancer, depending on the cancer type, the treatment, and the time elapsed since treatment (8, 19). Some authors assume a relationship between balance and cognition, which further corroborates the importance of that skill (20). Balance is defined as the ability to maintain the body's center of mass within the base of support (21, 22). It is one of the most important motor skills since it is needed in almost every activity of daily life. Positive effects of an intense one-week skiing program on balance abilities were observed in pediatric cancer patients previously (23). It remained unclear though whether skiing as a demanding physical activity led to the measured improvements or possibly the intensity of the activity (approx. 4 hours/ day). Systematic studies on balance abilities in pediatric cancer patients are rare, especially with respect to physical activity in rehabilitation (8, 24).

It has been stated that the specific connective tissue named 'fascia' is acting as a body-wide proprioceptive organ (25). According to Bordoni (26) the fascial continuum is essential for transmitting muscle force for correct motor coordination. Therefore it might be desirable to find a kind of fascia training that potentially enhances the critical aspect of balance. A training concept named 'Slidation' (composed of 'Slide' and 'Rotation') is used in the rehabilitation of pediatric cancer patients as a kind of fascia training. Slidation is characterized by dynamic movements on a slippery surface comparable to ice skating on the spot and it is performed with a certain position and various movement tasks (see 'Methods' section). One of the basic aims of Slidation is to improve core stability. An economization of movements should be achieved by intentional innervation of various muscle chains that became oftentimes inactive by one-sided stress, injury or imbalances of the tonic and the phaseal musculature, e.g. due to chronic diseases and being bedridden. Thereby it is desirable to have a low energy consumption which is achievable by an economical interaction of the locomotor system. The better the muscular interaction the more economical are daily movements or performances, such as ascending stairs or regaining balance on slippery surfaces. This economization of performances and improvement of muscular interaction should be achieved by the main principles of the Slidation movements, specifically sliding, rotation and extension of the spine. Hence the Slidation concept firstly considers the proprioceptive refinement principles of fascia training with respect to the body positions (abdomen contracted, belly button drawn-in towards the spine and extension of the spine) and the performance of quick micro-movements and large movement amplitudes according to Schleip (27). Secondly it involves a general enhancement of the core and thus balance and injury prevention (28, 29).

The aim of the current study was to evaluate the already implemented rehabilitation training concept Slidation and its effects on postural stability in pediatric cancer patients after acute chemo therapy during rehabilitation within a one-year-study. It was hypothesized that Slidation training is associated with a higher increase in postural stability compared to the conventional rehabilitation concept.

Materials And Methods

Ethical Approval

The Local Ethical Committee at the University of Hildesheim gave the approval. Informed consent was obtained from each participant in accordance with the Declaration of Helsinki.

Participants

For the current study a total of 25 pediatric patients (11.8 ± 3.2 yrs., 18 males, 7 females) were recruited in stationary rehabilitation facility to participate in an intervention study as the intervention group (IG) for the duration of four weeks. Another 32 children (12.0 ± 2.5 yrs., 16 males, 16 females) were tested as control group (CG) without an additional intervention, but they followed the regular routine which comprised physiotherapy, manual therapy, Swimming, horse riding or various kinds of non-physical treatments. All participants were pediatric cancer or hematologic patients, most of which suffered from acute leukemias (ALL = 5, AML = 1) Other entities were lymphomas (Hodgkin Lymphoma or Non Hodgkin Lymphoma, (n=6), brain tumors (n=6), bone and soft tissue sarcomas of lower extremities (n=3) and two other tumors (1 thoracic inflammatory myeloblastic tumor and 1 nephroblastoma). Aside from the oncologic patients two hematologic patients with anemias were included (1 aplastic anemia, 1 Blackfan-Diamond-anemia)

Procedures

A general Slidation training program was developed by the principle investigator which was carried out twice per week for about 45 minutes in sets of three and 20-25 repetitions which equates to approximately one minute of activity per set. Participants were recruited in a Rehabilitation Clinic for four weeks respectively. The study took one year in total, including four weeks of rehab with and four weeks without the Slidation intervention alternatingly. All participants left the facility after four weeks so that every second cohort could serve as controls. Before (pre) and after (post) the intervention period all participants were tested for stability abilities.

The training sessions comprise different exercises for standing, sitting, kneeling or lying positions. Required equipment is the Slidation board, felt shoes, knee pads, hand pads, sometimes a ball or a tight rubber band and a headlamp (figure 1).

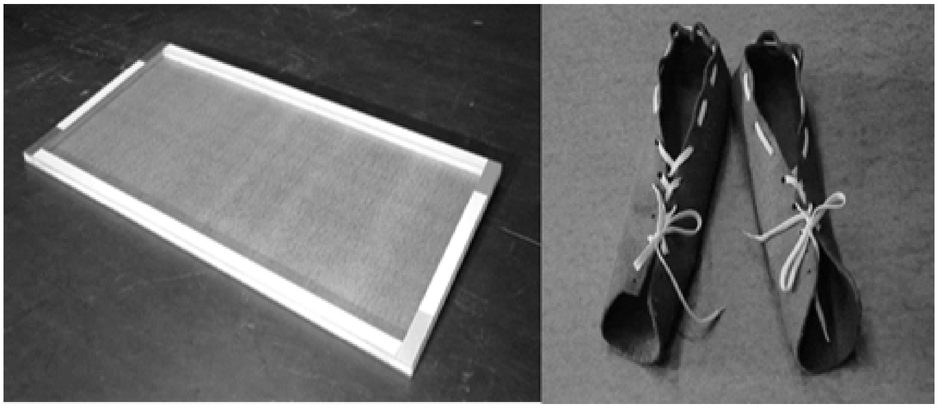

Fig 1. *Slidation-Board, Felt Shoes*

The Slidation board consists of a slippery surface which is surrounded by a wooden frame that is used to stop at in order to push oneself off and slide back to the other side.

Concerning instructions for execution it is essential that the patient retains and pronounces the S-form of the spine so that the lumbar lordosis is maintained while the abdomen is moved in towards the spine which leads to a contraction of the abdomen muscles and activation of the pelvis and the midriff. While maintaining that position the neck should be actively straightened upwards in a double chin position. A distinct rotational movement of the upper body rotators simultaneous to a pushing movement of the lateral leg should result in a sliding movement to the other side of the board. Arriving at the other side one needs to stop laterally and push back which entails a transmission to the tonic musculature via the inner rotators of the hips.

Those exercises that require a sitting, kneeling or lying position are focused on rotational movements in the shoulder cuff and the sliding movements are basically performed by the hands and lower arms while the deep spine muscles are trained to control movements.

It is more important to keep the position with a straight neck (double chin), a lumbar lordosis and a contracted abdomen than to meet the number of repetitions (approx. 25) or the set time (approx. 1 min.). The s-shape of the spine should be maintained, specifically neck lordosis, chest kyphosis, lumbar lordosis, as illustrated in Figure 2,a (Home Position).

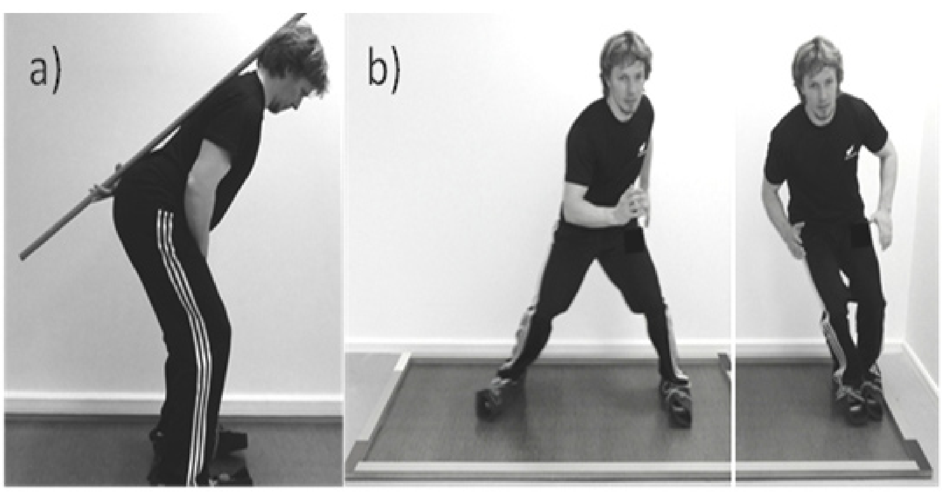

Fig 2. *a) Home Position (Three supporting points of the pole, neck- and lumbar lordosis visible), b) Basic Exercise (Sliding from side to side with lateral push under maintenance of the home position)*

The "Basic Exercise" comprises sliding sideways from side to side while maintaining the home position, stopping at the frame and pushing back to the other side (Figure 2,b). The Basic Exercise can be performed repeatedly as active set breaks. It is crucial to rotate the upper body without forming a block with the whole body and the arms should support the momentum. This basic exercise can be varied and modified by different leg or arm positions, partner tasks and utilization of additional equipment such as a ball, a rubber band or a laser lamp attached to the head.

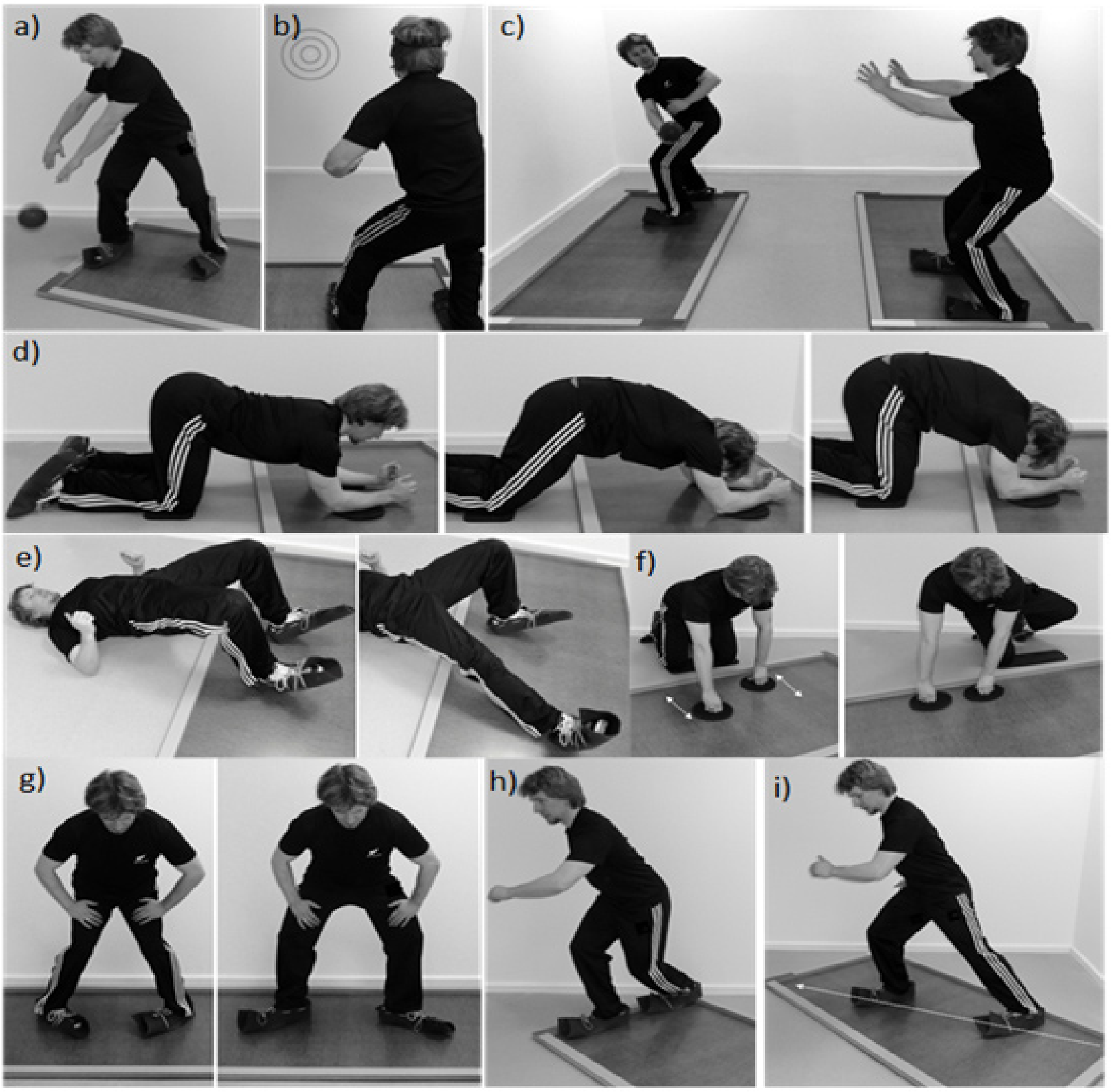

Fig 3. *a) Bouncer (Bouncing ball on the ground on the sides respectively), b) Laser Lamp (with laser lamp on the head trying to focus the pattern on the wall while sliding), c) Partner Ball diagonal (Two partners sliding and passing diagonally facing the same direction), d) Hump Cat (sliding forward with hollow back and sliding back with lower abdomen innervation and a hump while kneeling), e) Treading Water (same movement as in Water Polo swimming on the spot; lying on the shoulders and arms while straightening and flexing the legs in rotatory movements), f) Wiper (kneeling in front of the board, quick micro movements with the arms forward/ backward and to the sides), g) The Frog (standing on the board, heels are sliding to the outside and back to the inside; movement primarily activated from the butt), h) Cross Over (variation of the Basic exercise), i) Colors (variation of the basic exercise; sliding to a specific edge of the board that has the color that is announced from a second person→green, blue, red, yellow).*

The laser lamp should be focused on a pre-prepared pattern on the wall while sliding to the sides or executing different exercises. The participants executed nine different exercises plus several variations per training program in total.

Measures

The tests were conducted using a Posturomed (Haider Bioswing®) and the Posturokybernetik-Test (Microswing 6 measurement system, Version 6.03.00) as an evaluated procedure (30). All participants performed a single leg stance on a swinging platform with a 2-dimensional sensor attached underneath for calculation of postural stability.

The test involved the participant stepping onto the platform in a randomized order with the left and the right leg three times respectively, with the participant holding a pre-defined position for ten seconds on each trial. The ability to regain balance was measured for both the left and right leg. The mean values of the three trials per leg were calculated. The output measures describe the relative stability on the swinging platform and are indicated in %. Relative stability was assumed 100% when the person stands completely still, hence the lowest reachable stability measured by the Posturomed was 0% and the highest 100% (31).

Statistical Analysis

Comparisons of the change in balance over the time period between the groups (IG and CG) were calculated by one-way ANOVA while the comparison of the results of pre-test and post-test were analyzed with a paired T-test. P-values lower than 0.05 were considered significant. Statistical power was calculated using G-Power 3.1.9.2 with an effect size of 0.5 and a respective total sample size of 27 participants. All statistical analyses were calculated using IBM SPSS Statistics 23.

Results

Posturokybernetiktest

The IG achieved a stability increase of 11.08 % on the right leg from the pre-test to the post-test with a statistically highly significant change from the pre-post-comparison (p=0.000, Table 1). The mean values of the left legs changed significantly about 7.13 % from the pre- to the post-test (p=0.021).

The CG had a right leg stability increase of 8.56 % from the pre- to the post-test which turned out significant (p=0.002). The post-values for the left leg were significantly better than the pre-values (p=0.000).

The comparison between the groups for the pre-test showed a significant difference in favour of the CG for both sides (right p=0.016, left p=0.004). The post-test differed between groups significantly on the left side (p=0.007) also in favour of the CG. The right side also showed a significant difference between groups for the post-test (p=0.023).

Table 1. *Results of the pre-intervention (pre) and post-intervention (post) balance test of the Slidation intervention group (IG) and the control group (CG). Values given in percent, except for the P-Values. Significance is indicated in bold.*

	IG (N=25)		CG (N=32)		P-Value (One WayANOVA); Comparison between Groups	
	Right	Left	Right	Left	Right	Left
Mean and SD$_{pre}$	42,43 ± 3,71	45,47±23,01	51,57± 25,2	51,31± 22,46	**0,016**	**0,004**
Mean and SD$_{post}$	53,51± 21,69	52,6±22,51	60,13± 22,88	62,51 ± 20,46	**0,023**	**0,007**
***P*-Value(paired *T*-Test)**	**0,000**	**0.021**	**0,002**	**0,000**		
Coefficient of variation$_{pre}$	27.47	39.82	24.65	29.36		
Coefficient of variation$_{post}$	21.18	18.27	26.79	29.60		
Minimum value$_{pre}$	0	0	0	0		
Minimum value$_{post}$	7	0	0	0		
Maximum value$_{pre}$	79	88	84	86		
Maximum value$_{post}$	87	85	89	90		

Discussion

The aim of the current study was to evaluate the novel training concept Slidation regarding its potential to enhance balance abilities in pediatric cancer patients. A group of 25 patients participated in a four-week training intervention with eight sessions in total. The results show significant improvements in balance abilities tested by the Posturomed. However, the control group of another 32 patients without the specific intervention exercises also improved their balance values significantly within this period of time.

There are a few explanatory approaches, e.g. the intensity and execution of the intervention exercises might have varied quite decently due to the patients' daily variability of condition. Another considerable bias is the fact that therapeutic horseback riding (hippotherapy) was part of the rehabilitation program for half of the control participants which is meant to affect balance abilities (32). Liepert et al. (33) suggest that the critical variable in recovery may not be the nature of the therapy but rather the frequency and intensity with which it is delivered. Anyway, the IG improved and showed the same enhancement as the CG. These results could be interpreted the way that the Slidation concept might aid postural control and serves the mechanisms to enhance balance e.g. core muscle activation and/ or sensory motor activity as referred to by Willardson (34).

It could be assumed that previous therapy sessions on the testing day or breaks such as lunch time could influence the measurements. Thus additional testing sessions were conducted with selected participants during the intervention period at different times of the day (n=6). None of the repeatedly tested participants showed any significant differences between the start and the end of the therapy day within five measurement times.

Other training concepts have been evaluated on their influence on balance abilities in healthy adults. The so-called Slashpipe concept showed significant improvements regarding stability also measured by the Posturomed (35). It has been assumed that muscle adaptation during training situations on unstable surfaces or with unstable gear, e.g. free weights or weights consisting of liquid like Slashpipe, might lead to economization of movements due to improved postural control and thus the contracted muscle force can possibly better be focused on the sport-specific task rather than using it to compensate postural sway. It seems likely that this mechanistic reasoning holds true for the results of the current intervention.

The goal of intervention at the strategy level is to help patients recover or develop sensory and motor strategies that are effective in meeting the postural demands of functional tasks. Gill-Body et al. (36) conducted case studies, e.g. a rehabilitation treatment program for a patient with imbalance and dizziness following a cerebellar tumor resection. Improved steadiness during stance and gait were reported using a variety of both clinical and laboratory tests and measures, such as kinematic analysis of locomotor performance before and after the six-weeks-treatment. Posturography tests also showed an improved ability to respond to external perturbations to balance as it is the case in the current study. The authors concluded that patients with cerebellar lesions, whether acute or chronic, can significantly improve postural stability by following a structured exercise program (36). This requires, however, that the therapists exactly know the inherent requirements of the task being performed so patients can be guided in developing effective strategies for meeting task demands (37). Duncan's (37)results suggest that therapeutic exercises are associated with improved stability and that this improvement can have positive effects on functional skills. In contrast to quiet stance adults rely on somatosensory inputs in response to transient perturbations whereas children rather rely on visual inputs (38). In addition to the fact that investigations into the effects of postural control interventions in pediatric cancer patients are obviously underrepresented, the above findings underline the need for individual prescription of exercises on the one hand and individual monitoring on the other hand. The goal of intervention at the functional level focuses on having patients practice successfully the performance of a wide variety of functional tasks in many contexts. Since the ability to perform postural tasks in a natural environment requires the ability to modify strategies to changing task and environmental demands, developing adaptive capacities in the patient is a critical part of retraining at the task level (39).

Adaptive capacity for a variety of changing tasks could be trained by Slidation due to varying tasks and demands on the Slidation board which could train stability and flexibility for both sports tasks and daily life demands. Two unpublished Master theses from Münster/ Germany showed an economization in long distance runners in that the perceived training impact decreased and the needed recovery period was reduced after a Slidation intervention of eight weeks complementary to the normal running training (40, 41). They measured VO2max, lactate, heart rate and coordination and found significant changes compared to controls without the additional training of 45 min. twice per week. As the current study used the same training volume and intensity it might be worthwhile to investigate if less training volume (e.g. 25 minutes twice a week) had the same effect as then it would be highly time-efficient.

Further grey literature tested other motor driven skills such as flexibility, power, endurance, speed and agility and cognitive skills such as concentration, specifically working memory and shared alertness and found (partly significant) improvements compared to controls (42). However, this is the first published study giving pointers that the training concept may have the potential to be an efficient tool for retraining and/ or maintaining postural control which is deemed to be an important skill for cancer patients as it can decrease dramatically due to both the disease and the therapy and thereby compromise life quality (8). Additionally, the uniqueness of this training tool might arouse interest and motivation, particularly in young patients. This however, needs to be validated in follow up studies. It has to be shown in future studies whether combinations and different training intensities can also improve sport specific tasks and it would be of high interest if the gained results of the current study hold true for different patient populations and could possibly add further effects in terms of a rehabilitation enhancement.

More research is needed to examine the effectiveness of balance rehabilitation in general and the task-oriented approach specifically to the recovery of function. Beside postural control the topic of fasciae was initially mentioned as potentially relevant for cancer patients regarding balance improvements. Fascia has been described as a body wide tensional network, which is composed of all fibrous collagenous soft connective tissues (27). It can be considered as a wrapping material that wraps the human body underneath the skin and provides the body its actual shape. For the current study the parameter ‚balance' was of interest in the first place. As the investigated training concept Slidation is considered as a kind of fascia training (according to the definition of Schleip (27)) and fascia training is meant to be beneficial in different ways and Slidation is an already implemented training tool at some rehabilitation facilities, this concept suggested itself to be investigated as to be considered for further fascia training studies in the context of cancer diseases. Findley (43) speaks of anti-metastasis exercise and explored the possibility that active or passive mechanical forces applied away from the tumor itself may promote a healthy connective tissue environment that is inhospitable to cancer. Hence it seems vital to implement an efficient compensatory training to train the elasticity and resilience of the fascia, prevent fatigue, to enhance the general and specific capability and to counteract imbalances or movement constrains. Now that the feasibility of the Slidation concept has been proven, other possible and expected effects such as tissue changes could be investigated as the next step.

The ability to measure and quantify the properties of skeletal muscle and fascia in vivo as a method for understanding its complex physiological and pathophysiological behavior is important in numerous clinical settings, including rehabilitation (44). This remains a challenge to date due to the lack of a "gold standard" technique. However, there are recommendations regarding non-invasive imaging techniques such as advanced Ultrasound imaging or advanced MRI techniques for in-vivo biomechanical tissue movement analysis that might have the potential to provide more specific guidance to direct therapy and monitor tissue changes and detect more dense cancerous tissues. As these techniques become more widely used, the role of fascia in other conditions might become better documented and therapies might become more specific (45).

In conclusion, the training concept Slidation showed improvements for the critical parameter balance and may be considered as an additional training tool for cancer patients in order to regain stability.

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