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The one-ski-method—effects of an alternative teaching approach on selected movement patterns in alpine skiing

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Abstract: Teaching methods in skiing have marginally developed within the last decades. An intervention comparing the conventional approach (SP) and the One-Ski-Method (OSM) is proposed in which the main body actions are first trained on one ski and successively transferred to two skis. The OSM teaches the main body actions towards a proper position on parallel skis. The snowplow gets avoided as it implies obstructive body actions. Two groups were trained using each method. Video footage from the first and the fifth day were evaluated by experts following selected criteria. OSM learners showed significantly larger improvements compared to SP. Results indicate a faster acquisition of key elements of alpine skiing and provide a foundation for further investigations of the OSM method.

Subjects: Motor Control and Development; Skill Acquisition; Sports Performance Analysis; Biomechanics and Human Movement Science; Sport Education

Keywords: skiing; methods; beginners; instructions; learning

1. Introduction

Skiing is a lifetime sport offering a variety of different fields of activity ranging from easy slopes over challenging steep runs, moguls, parks to off-piste freeride areas. It has not been investigated what

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ABOUT THE AUTHORS

The authors of this article have experience in teaching skiing on various levels, and have conducted several international studies on snowsports since 2006. In general technique and equipment modifications regarding performance optimization and injury prevention were the main focus to date. In this context the aspect of motor learning is highly relevant as potential advantages of modified equipment may require to adapt from previously acquired movement patterns which are predominant and automatized (e.g. the use of a greater forward flex in ski boots). Therefore, targeted teaching methods appear crucial, particularly for novices, in order to acquire the required main actions without learning impedimental movement patterns. The group's activities thus extent from measuring dynamics, movement analysis and injury prevention to the evaluation and utilization of teaching methods. The OSM has been a part of our snowsport activities concerning both science and traineeship for about 20 years.

PUBLIC INTEREST STATEMENT

Motor learning in general is an underestimated challenge for any sports participant and children specifically. Thus it is important to choose specific and useful methodical steps. In the current study, an innovative teaching method in skiing was compared to the conventional method based mainly on the snowplow. The innovative method utilized main body actions to derive appropriate methodical steps. The One-Ski-Method (OSM) follows the aim to first train the body actions on one ski and successively transfer such skills to two skis. The two groups of young students (12–13 years) were filmed after the first and the last day and videos subjected to a blinded video analysis using generally accepted criteria for technical execution. Results indicate a faster acquisition of key elements of alpine skiing using the OSM. Further investigations are required to further investigate facilitation of motor learning in alpine skiing.

the most purposive way is for teaching and learning movements and body actions required for becoming a skilled skier. Generally, ski instructions and the methods of teaching how to ski for novices have not changed substantially within the last 100 years since the implementation of the first ski schools in Europe and the first guidelines (Borchert, 2012). It has to be noted that most ski school instructions are based on experience and with that potentially on a trial-and-error approach. Kassat (1985) investigated ski turns biomechanically in order to gain insights into the essential body actions required from skiers to actually bring their skis to a turn on the snow. His findings strongly indicate that the movement instructions used at the time and the biomechanical actions performed by proficient skiers were completely opposed to each other. It was further stated that the conventional method of using the snowplow (SP) as a basic skiing technique may be counter-productive. Therefore, a new methodological approach was derived (Kassat, 2000).

The current article will provide a summary of the principles and the differences of between the named approaches in simplified technical terms and the potential implications these may have for the respective method (Kassat, 1985, 1998, 2000). In order to derive an approach to learning and instructing a new movement it is vital to understand how this movement technically works. With this technical knowledge one can derive learning exercises with goals and sub-goals considering the relevant body actions to be acquired. The following sub-chapter will delineate the most important technical aspects as a prerequisite for the understanding of the current study.

This content could be interesting for ski lessons in conventional schools, for approaches of ski schools and particularly for the rather specific scope of rehabilitation. Sport in general has become an established area of rehabilitation for many diseases and the positive effects for both recovery and coping with the sickness are well known (Baumann, Jäger, & Bloch, 2012). In particular, skiing has been a topic at several winter sport camps within the follow-up care in pediatric cancer patients. For these events the major goal was to use the most efficient approach in order to reach a quick learning success with the feeling of safety and control on the slope. Concurrently, overstrain and a possible impairment of the mostly weak immune system need to be avoided. Hence, the results of this investigation will also be discussed in a clinical context.

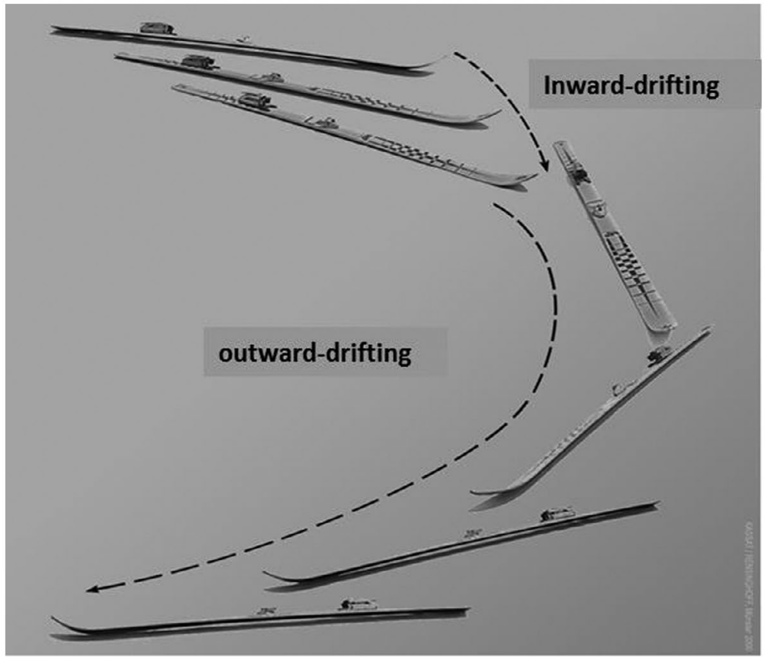
The current study was an attempt to proof whether or not the OSM is more efficient for beginners than a conventional procedure built around the SP. Conducting a comparative study with two basically different methods should give valuable pointers for practitioners. Further technical details and in depth explanations on the foundation of the OSM can be found in Kassat (2000, 2009).

1.1. Applied biomechanical analysis of the main elements of skiing technique

In the case of skiing, it is crucial to first find out *how the skis move* on the snow. Second, it is important to ask *by which effects this motion is created* and thirdly we can explore *which activities can produce these effects*. For the first question, Kassat's measurements (1985) revealed that a turn basically consists of two major parts, specifically the inward-drifting and the outward-drifting of the skis. In all turns, the skis change from the outside to the inside edges. At the onset of the edge-release the skis drift inward over the outside edges (tips faster) whereas after the edge-change the skis drift outward over the inside edges (tails faster) (Figure 1). There are situations in which the skis drift more or sometimes less and in so-called "carved turns" only a minimal drifting is visible and the edge-change takes place earlier, however these two phases of ski motion are always existent and every spray of snow to the sides is a proof of at least slight drifting.

For that lateral motion inward the skis must obtain lateral forces inward. Correspondingly, the skis need lateral forces outward for the motion outward which answers the second question. The third question which actions produce those effects now seems to be most relevant in terms of the whole system skis-skier as the skier has to influence this motion by means of specific body actions of which four have been identified (Kassat, 2000). The first major action is the inward movement of the centre of mass calling "falling-inward". By means of falling-inward the skis become able to slip sideways. Just

Figure 1. Inward- and outward-drifting of the skis within one turn (Kassat, 2000).

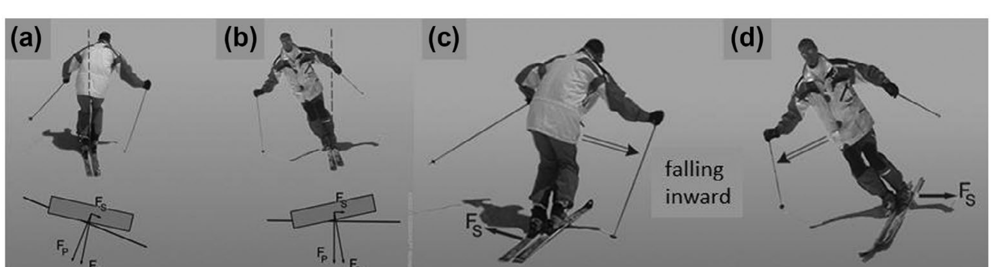


the lateral support of the skier F_{St} produces a lateral force inward F_S for the lateral motion when drifting inward (Figure 2(a)) and a lateral force F_S for the lateral motion when drifting outward (Figure 2(b)).

The action of "falling-inward" itself induces a reaction force F_S behind the centre of the skis as the bindings are located behind the midpoint of any ski. When drifting inward (Figure 2(c)) F_S avoids the drifting of the tails (against the mountain) and therefore the tips are drifting faster. When drifting outward (Figure 2(d)) F_S enhances drifting outward of the tails (after edge change). Hence drifting inward and drifting outward and thus parallel turns can be effected by means of falling-inward only. All essential conditions are fullfilled to perform the ski motion: *Edge-change*, *inclination*, *ability to slip laterally* and the generation of *lateral forces*. However, there are still three other main actions, so in total there are four main actions, named by Kassat (2000). The second activity is the so-called "ski-change" which describes lifting the inside-leg without shifting the body's center of mass. As the base of support is partly withdrawn the ski-change immediately causes falling-inward and all previously named essential conditions are fulfilled to perform the ski motion. The third main action is the "counter rotation action" which means the lateral motion changing from one relative angulation of the upper body against the lower body in the frontal plane to the opposite relative angulation which again leads to the preconditions for the ski motion (*Edge-change*, *inclination*, *ability to slip laterally* and the generation of *lateral forces)*.

The fourth main action is "leaning forward/backward" (Figure 3). After the beginning of the ski turn the sum of the friction forces at the edges (F_{fr}) acts approximately at the centre of the skis (M_S). The friction force is working eccentrically in relation to the axis through the centre of gravity (A). This

Figure 2. Effect of falling inward and its lateral support (Kassat, 2000).



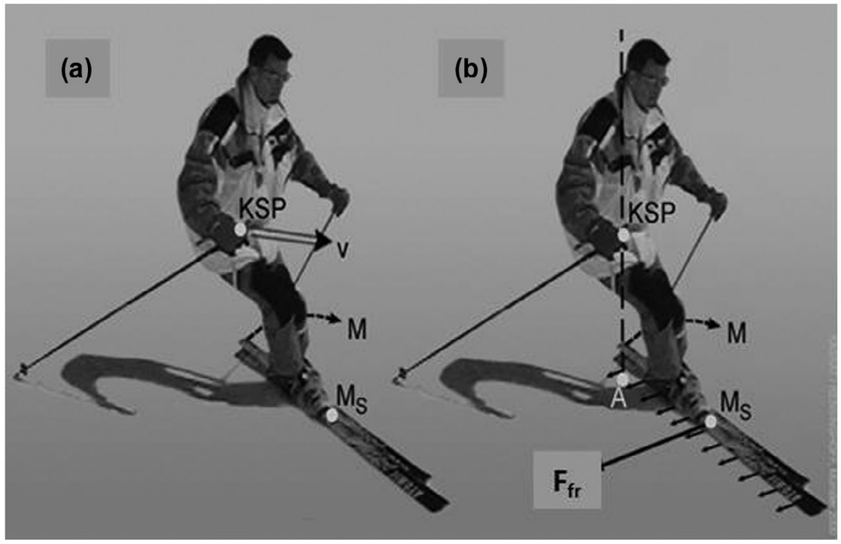


Figure 3. Influence of leaning forward and backward on the torque (Kassat, 2000).

way, the skis get a corresponding torque (M) and the skier can control the intensity of drifting outward by means of leaning forward or backward and thus increase or decrease the distance of the centre of gravity to the centre of the ski. It is illustrated that a skier does not turn the ski actively himself, but the reaction forces and moments of the slope turn the skis. However, the skier has to provide the contact between the snow and the skis by means of the four main actions. Additionally, the dynamic balance as another requirement is important for successful turning and is continuously adjusted by the radius and the velocity.

In the conventional understanding of turning an active leg rotation is still one of the prevailing main actions (Skilehrerverband, 2012). An active leg rotation in skiing, however, is not possible from a biomechanical point of view as the edges are always directed against the slope and it is questionable where the pivot point should be located. From a physiological point of view the knee joints could in no way stand such a great torque. As experimental support for this argumentation, a study has shown that muscles that are responsible for leg turning were inactive while performing parallel ski turns using electromyography (Renner, Waibel, & Huber, 1996).

The identification of these four main body actions provides a new conceptual framework which allows for a critical evaluation of existing teaching methods and, more importantly, for biomechanically based development of new instructions. Kassat (2000) developed the so-called "One-Ski-Method" (OSM) which aims at simple, quick and safe learning. As the method is the way to a goal, in this case the skiing technique, the method has to be deducted from the main actions required to execute a ski turn. The basic idea is to avoid the snowplow and stemming as those activities are not directly leading to parallel skiing and were originally based on different technique assumptions. "We do not deny that we see the stemming positions as a necessary evil and that we do in no way mean to base further instructions on them" (*translated)* was written in the early German guidelines from 1950 (Möhn, 1950). However, no appropriate alternative has been offered by the ski associations to date. The strategy of the OSM is to initially learn on one ski and subsequently transfer the learned movement patterns to two skis. The advantages should be to have one leg on the ground or a free leg at minimal speed, to be able to concentrate on one ski only and thus to allow the learner to experience and internalize perceptional feedback from errors as well as successes. Furthermore, learners should perform less reluctant and adjust themselves to a desirable position straight from the beginning and, as a side effect, getting up after falls is facilitated.

Initially there are various simple exercises including pushing, gliding and edging on one ski at virtually no or very low speeds. After fundamental customization to the position on the ski and gliding

Figure 4. Learning by using a long pole.

properties of the gear a large pole may serve as a methodical learning aid at the inside of the curve (Figure 4), for psychological reasons on the one hand, while implying a regulated inclination at low speeds, on the other hand (no dynamic balance yet, but no snowplow necessary).

2. Methods

A group of 28 participants (12–13 yrs) took part in this study who were all students of a high school in Western Germany and randomly assigned into 2 groups. Fifteen participants were in the group of the OSM (8 females, 7 males; 12 yrs ± 0.31) and another thirteen in the group of the SP (5 females, 8 males, 12 yrs ± 0.58). The Local Ethical Committee gave the approval. Informed consent was obtained from each participant in accordance with the Declaration of Helsinki.

After a short phase of familiarisation including free moving exercises, small games and relays on one ski, the OSM-group learned to ski on one ski first following the principle that the ski-leg and the free leg were swapped regularly and both the outside and the inside ski-legs were trained using the large pole (Figure 4). After the first half day, the OSM-group added the second ski and was guided by specific exercises to transfer the learned movements to two skis. On the second day, OSM learners changed from skiing with the large pole to the normal ski poles. No detailed explanations of specific exercises will be presented within this article, but the main characteristics of the technique should generally be perceived while standing and at low speeds. Moving on the inside ski (as ability to "play" with the balance and imbalance and gain more control in all skiing situations) was learned from the beginning on (using the long pole as methodical helping gear). Following a short period of basic education, it is usually possible to ski with the long pole parallel and two skis at the second half of the first day. Within the development of this method it was stressed repeatedly that learners need to be given the opportunity to feel how their body actions lead to ski movement, in fact that "the slope turns the ski" (Kassat, 2009).

The SP-group learned with two skis from the beginning using the conventional way using the snowplow (DVS, 2007; Skilehrerverband, 2012). From the second day on they tried to reduce the snowplow position in order to get to a parallel ski alignment.

All participants were instructed to fill out a questionnaire independently at the end of the first day and again at the end of the fifth day ranking their individual perceptions of the course regarding fun, safety, control, level of exhaustion, clarity of instructions, feasibility of following the instructions, perception of their own failures, satisfaction with their own success. This survey was constructed inductively via observations and deliberation of field documentations and served as an additional tool to partly compare the students' self-perception with the third-party video analysis. A five-answer-Likert-Scale was chosen to have the option of a neutral response. All participants were filmed with a video camera from the front view, partly from the side and the last turns from behind for approximately ten turns at the end of the first day and at the end of the fifth day. The footage was anonymised, randomised and sent to two independent experts for evaluation. The experts were professional level-4 instructors working for the German federation of ski instructors (DSLV) and had both 20 years of experience in instructing and analysing skiing technique. The criteria for analysis were fundamental technique aspects for good parallel skiing (Skilehrerverband, 2012) and chosen in agreement with the expert evaluators:

- Skis parallel
- Position on the ski (front lean position)
- Canting
- Tight upper body
- Pole planting
- Tilting the knees
- Smooth/fluent turns

The criteria were rated from 1 (very poor) to 10 (excellent). The groups were compared after the first day for all seven criteria and after the fifth day respectively. Subsequently, a comparison within the groups from the first to the fifth day was conducted. All data were analysed using a T-Test in Microsoft Excel 2010.

3. Results

The participants of the OSM-group ranked the items "control", "feasibility of instructions" and "satisfaction with own progress" significantly better than their counterparts of the SP-group after the fifth day. All other items were either only slightly better for the OSM-group or even such as the factor "fun". There were no major differences after the first day.

All items were ranked better for the OSM-group after the fifth day compared to the SP-group. The evaluation showed significant improvements for the OSM-group in the criteria "parallel skis", "position on the ski", "pole planting" and "tilting knees" (Figure 5). There were no significant differences after the first day.

Figure 5. Items of the questionnaire in a ranking from 0 (worst option) to 10 (best option) after the sixth day (n = 28).

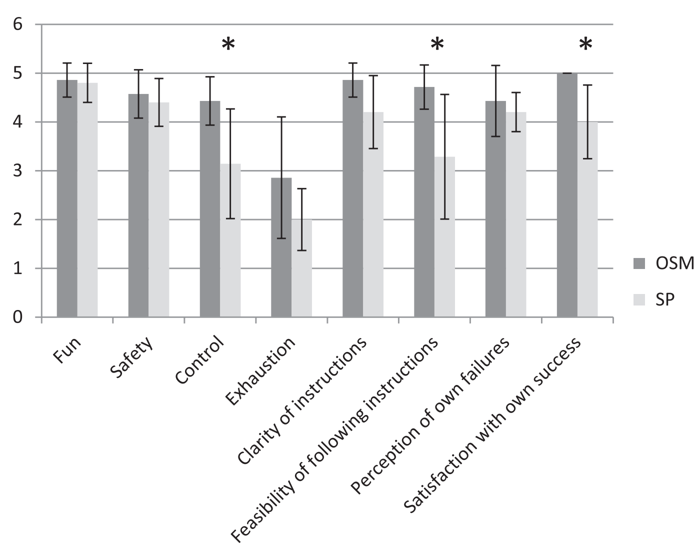
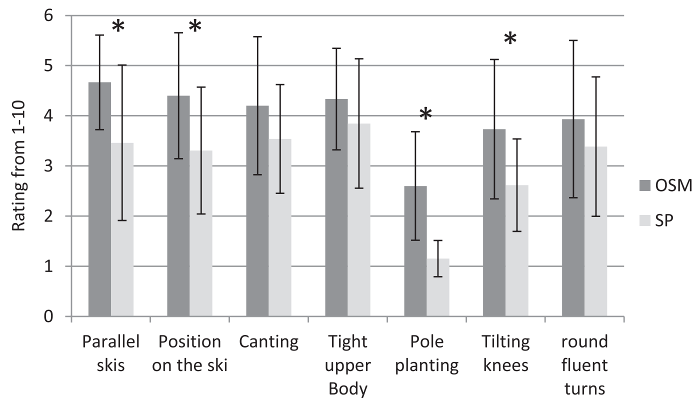


Figure 6. Results for seven selected movement criteria in a ranking from 0 (worst option) to 10 (best option) after the fifth day (*n* = 28).



4. Discussion

The current study compared the outcome of two different methods to instruct skiing on the first and the fifth day. Apparently, after five days of skiing there were obvious differences towards improved movement patterns in the OSM-group (Figure 6). According to Kassat, there are various reasons to explain the advantages of the OSM compared to the conventional way of the snowplow. The snowplow method seems to be a detour as beginners initially learn movement patterns that are opposed to the final, desired sports technique. It is common belief that the snowplow serves to provide security as the beginner has a wider base of support that is supposedly more stable. However, after learning the snowplow the next learning step is to unlearn this kind of body position and the related body actions in order to gradually approach skiing with more parallel skis. This learning step may be considered counterproductive and highly unreasonable from a learning-theoretical and neurophysiological point of view.

While the underlying mechanisms of motor learning are far from being fully understood, more and more evidence is accumulated which suggest that spinal plasticity makes up a substantial component in the acquisition of new motor skills. It is generally perceived that the processes of long-term potentiation and long-term depression are synergistically acting within the process. These processes entail the successive weakening or strengthening of synaptic connections leading to structural changes in the neural architecture (Lee, Rhyu, & Pak, 2014). In a review, Thompson and Wolpaw (2014) underline that the spinal cord in itself is susceptible to a much greater extent of plasticity changes than previously believed. Further, this spinal plasticity is largely influenced by physiological influences from the brain. In their studies, they demonstrate that basic reflex responses can be altered by operant conditioning which leads to functional adaptations in animals as well as humans. It is argued that such local physiological adaptations in the nervous system lead to broader beneficial changes in the central nervous system with widespread adaptive changes which lead to an expanded motor action repertoire by providing the opportunity for a new "negotiated equilibrium" within the motor control system (Thompson & Wolpaw, 2014) leading to improvements in learning. Further, it has specifically been reviewed that the developments of sensory systems and motor systems are reciprocally linked (Ostry & Gribble, 2016) and that a coupled development of both systems is especially advantageous for motor learning. Taken together, these basic physiological mechanisms make it perceivable that the practice of biomechanically different motor actions including the provision of contradictory sensory perception may be particularly misleading to a novice when learning a new motor skill.

At the cortical level, motor maps are formed which are related to the capacity of executing complex motor skills. Such motor maps can be attributed to areas of synaptic activity in the motor cortex in relation to specific tasks and get reorganized during the acquisition of a new motor task. Synaptic plasticity based on the above mentioned mechanisms builds the foundation of motor map reorganization. It has been indicated that sufficient repetition of movement sequences is required to form and establish a motor map within the motor cortex which may represent a motor engram (Monfils, Plautz, & Kleim, 2005).

Referring to the described fundamental physiological processes, neuropsychologic learning theories propose that after having acquired a new skill, i.e. the snowplow, an engram for this specific movement pattern has been created in the motor cortex within the brain. It becomes now more challenging to alter such an engram in a similar context, or to trigger a different motor action and save this as a new pattern in a new engram or alter the existing one. The first, originally saved pattern would always be triggered first and making it harder for the novice to apply the key movements as required.

One solution could be to methodically bypass the unconscious retrieval of that motion program by modifying the task or the situation that triggers the retrieval. In the current application, this could be managed by introducing the initial exercises on one ski which makes it impossible to stem or use the snowplow, or alternatively, to use the large pole with two skis which would make the snowplow unnecessary. However, the obvious and more suitable solution would be to avoid the adoption of such motion patterns in the first place by learning the appropriate principles with one ski, or with two skis kept parallel, by using the outlined methodical preparation. To unlearn a programmed movement or to overwrite a saved engram in the brain is the main challenge and a widely underestimated problem in movement science.

There is a biomechanical difference between the goal technique and the snowplow. The latter comprises standing on two different and opposed edges which is never the case in skiing apart from the snowplow. Additionally, performing the snowplow the centre of mass is shifted to the outside of the turn which is never the case in skiing apart from the snowplow and is therefore contradictory to the mechanisms of learning. The practical implications of this dilemma have been realized in some official ski instruction manuals early on, as the Austrian ski instructors state: “The straddle position of the snowplow leads to cramped skiing for beginners to which they tend anyway” (translated) (Österreichischer-Berufsskilehrerverband, 1957). Also, Gattermann (1981) had the awareness about 35 years ago that there is no comprehensible transition from stemming to parallel skiing. This indicates that the conventional way through the snowplow was thought of as an undesirable movement step about 60 years ago already. Apparently, there has not been an appropriate alternative apart from the OSM method.

The significant items of the evaluated selected movement criteria (parallel skis, position on the ski, pole planting, tilting knees) are basic necessities for parallel skiing and criteria for good skiing in challenging environment for experienced skiers (off-piste, parks, moguls, powder etc.). These criteria are trained right from the beginning employing the OSM and the respective exercises with the focus on the position and perception. Due to the direct feedback and one foot on the ground at the start and a free leg at low speeds motor learning is likely to be enhanced and the students can transfer the learned movement quickly to skiing on two skis which leads to improved control and finally to a satisfaction with the own learning progress (Figure 5).

Despite Kassat’s biomechanical findings and an experimentally founded teaching concept which has been used for many years no official ski school or federation has ever adopted his approach to date, apart from Universities and High Schools in Western Germany. This appears inapprehensible, however, it seems to happen within many scientific traditions as Planck stated: “New findings do not become accepted by convincing the opponents, but by their extinction” (Max Planck). The phenomenon that new findings are usually not directly adopted and accepted is well known and the inventor of the OSM perceived this as normal and understandable as a part of the previous philosophy or ideology gets turned upside down.

4.1. Application to clinical contexts

As initially stated, skiing is a life-time sport and it has entered the scope of sport therapy as seen at a project of the University of Hildesheim, Germany, in cooperation with the Medical School Hannover, Germany. For example, rehabilitation weeks in the mountains with children suffering from cancer are undertaken with the sportive focus being on skiing. For those specific clients an economic approach with the prospect of feelings of success is particularly important for rehabilitative goals whereas fear, frustration and excessive demands are to avoid. The OSM has been implemented as a teaching method for the named project and led to several successes for handicapped beginners who are commonly weaker and coordinatively less proficient than their healthy counterparts.

The advantages for young patients with a lack of physiological reserves and self-confidence are obvious: The concentration on only one ski supports the feeling of control and safety and so-called "panic moves" such as backward lean positions are rather rare. Those backward lean positions may lead to common injury mechanisms (Hunter, 1999) and would therefore jeopardize the overall goal of a comprehensive recovery. Safety and fun are the most important aspects in skiing as a rehabilitative event. A good technique execution in the sense of advantageous position and relevant body actions in that context is rather secondary, however, this approach apparently pools all of these aspects. This in turn can lead to the feeling of success and motivation to keep going.

The item "fun", also retrieved with the questionnaire, was the same for both groups and therefore did not decline for the OSM group. One can assume that this factor would be even higher in a group of handicapped learners using the OSM approach as the point of having less physiological reserves than healthy people is meaningful. The faster acquisition of key elements of alpine skiing thus would be particularly beneficial for patients with regard to the factor "fun" and sustainably keep their activity level up by skiing. However, it needs to be investigated if the current results hold true for patients, e.g. by questionnaires on future rehabilitation trips.

As previously discussed unlearning a known movement in order to modify the execution is more challenging than to learn a new motion. As most of the cancer patients have limitations in regard to either their coordination or concentration, or both, due to the side effects of the treatment or other physical or mental handicaps, learning capacity as such may be reduced anyway. Thus for their instructions a direct approach with a maximum of safety and a good prospect for a sportive success should be chosen rather than neglectfully choosing an obstructive way. The experiences and the current results could be understood as a pointer towards future approaches with children, adults or patients likewise.

5. Conclusion

The current investigation has provided pointers towards the OSM having the potential to aid learning successes in young students in alpine skiing. Significant improvements of the aspects parallel turns, position on the ski, pole planting and tilting knees as well as the retrieved perception items control, feasibility of following instructions and satisfaction with own success provide support for this assumption.

Further studies may be required to attest if the OSM provides similar advantages of different groups of healthy learners interested in skiing. It would need to be investigated if various age groups of beginners would show similar benefits of using this alternate method of skiing instructions. In regard to the mentioned potential benefits for clientele recruited from patient groups with special needs, future studies would be required to include effects on physiological exertion measuring heart rates or further evaluate the efficiency of the OSM with different handicaps.

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