

Practicing sports in lucid dreams – characteristics, effects, implications

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COMMENTARY

Article History:

Submitted 22th June 2017

Accepted 25th May 2018

Published 29th June 2018

Handling Editor:

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ABSTRACT

In a lucid dream the dreamer is aware of the dream state and can carry out actions deliberately. Lucid dream practice (LDP) is the rehearsal of movements during lucid dreams and constitutes a specific form of mental practice (MP). Previous studies demonstrated that LDP can enhance physical performance. To gain deeper insight into LDP on a qualitative level, sixteen semi-structured interviews were conducted with lucid dreamers from different countries. Inductive content analysis revealed that many different sports and movements can be practiced in lucid dreams. LDP experiences were very realistic, including kinesthetic perception. Required equipment or sparring partners usually were available or could be created and adjusted by the athletes. Thirteen interviewees (81.3%) reported positive effects of LDP. In particular, 10 participants reported to have improved their physical performance through LDP, confirming findings of previous studies. Other positive effects were, for example, strengthened confidence, insights for physical practice (PP), improved flexibility, and positive emotions. The results also demonstrate the special possibilities of LDP like deliberate manipulation of practice conditions, speed, and perspective. Furthermore, problems occurring during LDP are described and how they can be dealt with. Based on the results, practical advice for interested athletes is provided. In conclusion, the present study demonstrates the great potential of LDP for sports practice. LDP could also be applied in other areas that involve motor learning, like rehabilitation, music, or surgery. The present study complements previous LDP findings and provides input and new ideas for future LDP studies. Furthermore, it is an important contribution to general MP research. Findings from LDP research—a small but growing field—should be incorporated into conceptual discussions on MP. Also, by extending LDP research, athletes and coaches could become more aware of this unique and effective method and could start to integrate it into sports practice.

Keywords:

lucid dream practice – mental practice – lucid dreaming – motor learning – interview – qualitative

Citation:

Schädlich, M., & Erlacher, D. (2018). Practicing sports in lucid dreams – characteristics, effects, and practical implications. *Current Issues in Sport Science*, 3:007. doi: 10.15203/CISS_2018.007

Mental practice (MP) can be defined as “cognitive rehearsal of a task in the absence of overt physical movement” (Driskell, Copper, & Moran, 1994). A plethora of experimental studies has demonstrated that motor skill-learning benefits from MP in various domains such as sport, music, medical surgery, and neurorehabilitation (cf. Fargier, Collet, Moran, & Massaerelli, 2016). While the term “mental practice” is usually applied to rehearsal

while awake, it can be extended to the dream state: A lucid dream is a dream in which the dreamer is consciously aware that he or she is dreaming and can thus decide to carry out specific actions (Schredl & Erlacher, 2004). Lucid dreams mainly occur in REM sleep (Erlacher & Schredl, 2008). A method of verifying lucid dreams is by eye signals which can validate verbal dream reports (also see Schädlich, 2018): While lucid, dreamers

can deliberately move their eyes in a distinct pattern, usually a fast repeated left–right movement which can be detected in the electrooculogram. The application of movement rehearsal in lucid dreams, lucid dream practice (LDP), was first studied by Paul Tholey (e.g. Tholey, 1990). Similar to general MP research (cf. Malouin, Jackson, & Richards, 2013), studies found correspondences between LDP and physically executed movements supporting the conception that physical and dreamed movements share the same neural substrate (cf. Schädlich, Erlacher, & Schredl, 2016). In a questionnaire study Erlacher, Stumbrys, and Schredl (2011) showed that out of all athletes who have lucid dreams 9% practiced motor skills in lucid dreams—77% of those reported to have improved subsequently. These numbers reinforce anecdotal reports of amateur and professional athletes who effectively used lucid dream practice (cf. Tholey, 1990; cf. Erlacher, 2007).

Three quantitative studies demonstrated that enhancing athletic performance through LDP is possible: In two field studies lucid dreamers improved their performances in a coin-tossing task (Erlacher & Schredl, 2010) as well as a finger-tapping task (Stumbrys, Erlacher, & Schredl, 2016). Schädlich, Erlacher, and Schredl (2016) investigated LDP in a sleep laboratory study employing a dart throwing task: The dream reports revealed that experiences differed strongly concerning the number of distractions (e.g. by dream characters) experienced during LDP. A post-hoc analysis showed that the lucid dreamers with few distractions during LDP improved significantly over time whereas the ones with multiple distractions did not. Although these findings are only preliminary, they elucidate the necessity of an extensive qualitative study. Furthermore, in a qualitative study numerous LDP experiences can be analyzed, which are independent of pre-determined study tasks. Only one qualitatively study investigated LDP (Tholey, 1981): Six experienced lucid dreamers reported that they were able to carry out familiar complex motor skills in lucid dreams without difficulties. The participants also reported positive training effects within the dream as well as on waking performance.

Our goal was to demonstrate a variety of LDP experiences, to confirm positive effects found in other studies, and to derive implications for sports practice. Our main questions were: What are the effects of LDP on physical performance? Does LDP provide special possibilities? How are movements and other features perceived? What problems occur and how are they dealt with? What can we learn from the interviewees' experiences?

Methods

Participants

Sixteen lucid dreamers were interviewed. Participants' characteristics are depicted in Table 1. Participants were required to have performed sports they were familiar with from physical practice (PP) in at least one dream during which they were aware of the dream state. Via emails the first author ensured

that the potential participants had understood the definition of lucid dreaming by asking for examples and asking further questions if necessary. Interviewees (*N* in parentheses) were from Germany (9), the United Kingdom (3), Norway (1), Spain (1), the United States (1), and New Zealand (1). Mean age was 32.9 ± 7.9 years at the time of the interview. With two exceptions (P04, P09), participants practiced at least one sport in an organization. Participants were recruited via advertisements in internet forums, online journals on lucid dreaming, posts on social networking sites as well as via personal contacts.

Interview guide

Based on our main questions, the first author developed a draft of a semi-structured interview guide which was then sent to several sports scientists and lucid dreamers and adjusted according to their feedback. The complete interview guide contained few closed and many open questions. Some questions were based on previous findings or anecdotes. For example, in Tholey's (1981) study participants jumping and spinning in lucid dreams led to peculiarities. So we specifically inquired about gravity, jumps, and turns. We also included questions about the dream environment, equipment, partners etc. In order to relate the possible effects of LDP to the interviewees' goals we also inquired what their motivation was to practice sports in lucid dreams. Table 2 depicts all questions, sorted by sections. The first author translated the interview guide into English for non-German speakers. During interview conduction the ordering of questions usually followed the interview guide but deviated when the interviewees spontaneously addressed a different issue. Whenever it appeared interesting to gain more information, the interviewer asked additional questions.

Data collection

Fifteen interviews were conducted via a free internet telephone service and recorded via a connected recorder program. One interview was conducted via landline telephone and recorded by digital voice recorder. The first author conducted all interviews in German (native tongue) or English (fluent). Fourteen interviews were conducted in the participants' native language (German or English); the Norwegian and Spanish lucid dreamers were fluent English speakers. The original interview guide contained more questions which are not analyzed in this study. The interviews lasted between 35 and 210 min, with an average duration of $89 \text{ min.} \pm 46.8 \text{ min.}$ In some cases participants sent additional information via email, for example, extracts from dream diaries. Passages that were unclear during transcription as well as skipped or misunderstood questions were sent to the participants via email and the email responses were added to the interview transcriptions.

At the beginning of the interview participants were informed that we wanted to find out more about the experiences and potential effects of motor practice in lucid dreams. Furthermore, they were informed that participation was voluntary and

Table 1: Overview of participants and lucid dream practice experiences

Code	Sex (m/f)	Age (years)	Lucid dream frequency ^a	Number of LDP dreams	Skills/ competing level	Overview of LDP experiences
P01	m	31	6	3	Kickboxing: green belt	Martial arts^b: Kata (form), specific kick combination
P02	m	21	7	58		Kung Fu: spears, sparring, Tan Toi positions
P03	m	27	7	2	Karate: regional	Karate: techniques
P04	f	23	7	43		Alpine skiing: having fun, jumps and salti (things she cannot do in waking life) Gymnastics: short routine for laboratory study
P05	f	39	7	400	Yoga: teaching	Juggling: basic technique; Yoga: postures, stretching; Swimming
P06	m	53	6	8		Mountain biking: e.g. impossible descents, balancing, racing, tricks
P07	f	29	7	2		Breakdance: choreography; Dancing: choreography (experimenting)
P08 ^c	f	29	7 ^c	95 ^d	Taekwondo: Red belt with black tag/ local	Taekwondo: basic forms and techniques, sparring Riding: jumping fences, dressage
P09	m	29	4	1		Cross-country skiing: continued skiing from before non-lucid dream
P10	m	35	6	7		Aikido: specific combinations, stick forms
P11	m	41	7	>100	Diving: teaching, under water filming	Diving: keeping balance/ stability in current, getting used to the environment Climbing: enjoys the thrill and flow like in waking life; Football: having fun
P12 ^c	m	28	7 ^c	>1000 ^d	Gymnastics: invited to compete on national level	Swimming: flip turn, basic styles for exam; Gymnastics: fine-tuning specific elements/ routines; Rugby: e.g. tackling, fine-tuning flight, strategy; Judo, CrossFit, Snowboarding, Bouldering,...
P13	m	36	7	5		Taiji: sequences (Yang style); Skating: skating downhill, deliberately exaggerating
P14	m	29	7	13	Kickboxing: black belt, first dan/ local	Martial art^b: sparring, specific jumps and kicks, practice for black belt; Breakdance: improving specific moves; Parcour, Skate boarding, Surfing, push-ups
P15	m	36	6	75 ^d	Karate and Kickboxing: black belt/ international (Kick-boxing ^e)	Taiji /Qi Gong: walking forms, experiencing movements and body on a deeper level Martial arts^b: sparring, practicing specific jumps and kicks, experimenting Push-ups: experimenting (how many he can do in a lucid dream)
P16	m	40	6	>1000	Taiji: Teaching	Taiji: e.g. forms, creating new movements; Taekwondo: Fighting Football: e.g. fancy goals; Alpine skiing: impossible jumps

a) Scale from 0 to 7 (0: never; 1: less than once a year; 2: about once a year; 3: about 2 to 4 times a year; 4: about once a month; 5: about 2 to 3 times a month; 6: about once a week; 7: several times a week)

b) Combat sport (different styles)

c) Participants are lucid in almost every dream since early childhood ("natural" lucid dreamers)

d) At times practiced regularly in lucid dreams (at least once a week)

e) Irish Gold, European Gold, World Silver, European Silver

Table 2: Semi-structured interview guide

Section	Questions
Lucid dream practice experiences	<p>How often did you <i>spontaneously</i> practice sports in lucid dreams? How often did you <i>deliberately</i> practice sports in a lucid dream? What motivated or triggered your lucid dream practice? Please describe one or more dreams and what movements you practiced.</p>
Specific applications	<p>Have you ever practiced in a lucid dream... ...to support learning a new movement? /...to improve a specific movement? ...to become more confident or fluent? ...to correct a mistake? ...to improve a more general skill, like power or balance? ...to improve tactics (team sport)? ...to complement physical practice? ...when you were not able to practice physically? ...to prepare yourself for a contest or a similar event? ...to mentally prepare yourself (e.g. reducing anxiety)? ...to adjust to certain situational conditions like a new or changed training environment?</p>
Specific characteristics	<p>Please describe what your movements during lucid dream practice in general felt like. Please describe in what ways movements during lucid dream practice felt different compared to wakefulness. How did you perceive (...) during lucid dream practice? ...gravity ...muscle power ...jumps and turns ...balance ...surroundings and equipment Please describe your (...) during lucid dream practice. ...visual impressions ...acoustic impressions ...perception of other senses, like smell, taste, temperature or pain.</p>
Problems	<p>What problems did occur? How did you deal with them?</p>
Effects	<p>Did you ever get the impression that your motor performance improved <i>while</i> you were practicing in a lucid dream? Please describe these experiences. Did you ever get the impression that your motor performance <i>in wakefulness</i> improved <i>as a consequence</i> lucid dream practice? Please describe these experiences. In what other ways has your lucid dream practice influenced your performance in wakefulness?</p>
Manipulation	<p>Have you ever manipulated speed during lucid dream practice, like moving slow motion or sped up? Please describe these experiences. Have you ever actively constructed or changed your environment during lucid dream practice? Please describe these experiences. Have you ever summoned a coach or another person to assist with lucid dream practice? Please describe these experiences.</p>
Evaluation	<p>Please describe the most positive experience you had with lucid dream practice! Please describe the most negative experience you had with lucid dream practice! Have you ever learned or experienced anything completely new during lucid dream practice, like a new body sensation or a new idea for waking practice? Do you think you will use lucid dreams again to practice movements in future? How intensely and in what ways do you want to use lucid dreaming in the future? What is most important for you about lucid dream practice? Who do you think can benefit from lucid dream practice? Who can benefit from lucid dream practice Are there any preconditions for learning lucid dream practice or for benefiting from it?</p>

that quotes will be anonymous. All participants gave written consent to participate. The study was approved by the ethics committee of the Faculty of Behavioral and Cultural Studies of Heidelberg University.

Data analysis

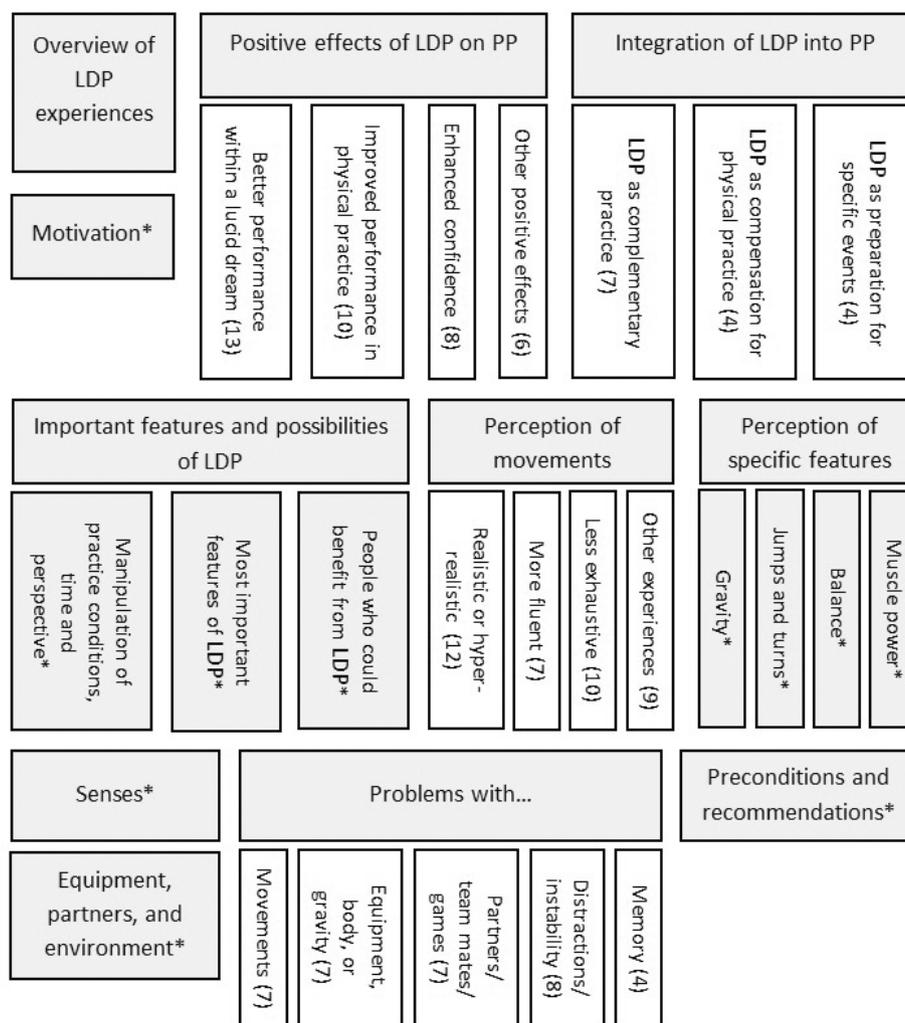
All interviews were digitally recorded and then transcribed verbatim by the first author. Parts of the audio files that were unrelated to the study were deleted and not transcribed. The transcriptions revealed that the participants had jumped a lot between questions. Therefore, the first author sorted the answers as well as additional email material in order to have a complete data set for every participant, following the structure of the interview guide.

Inductive content analysis according to Mayring (2000) was used to obtain higher and lower order themes from the tran-

scribed interviews. The first author familiarized herself with the material by transcribing, sorting, and re-reading the interviews. She then identified themes of interest and started creating themes from the answers by clustering quotes from the interviewees. Subsequently, the second author reviewed the preliminary theme framework and discussed it with the first author after becoming familiar with the raw interview transcriptions. The first author then adjusted the themes. This process of discussing and adjusting was repeated several times until both authors agreed on the final higher and lower order themes.

Results

Figure 1 depicts an overview of all the results section. In text, + indicates where additional quotes for a theme or example are provided in the supplementary material.



Note: Grey boxes represent result sections and higher order themes (when marked with * lower order themes are presented in the text). White boxes display lower order themes. Abbreviations: LDP: Lucid dream practice; PP: Physical practice.

Figure 1: Overview of results sections

Overview of lucid dream practice experiences

Table 1 provides an overview of LDP experiences, showing the number of LDP dreams per participant (estimated when multiple) as well as short descriptions of the sports and movements they practiced. Examples and quotes of LDP experiences are presented within the following sections. Quotes from German interview transcripts were translated into English by the first author.

Motivation

The motivation between the interviewees to apply LDP varied: Altogether, 11 participants used LDP for at least one particular purpose regarding their sport: Nine interviewees used LDP to generally complement PP, substitute PP, or to prepare for events like competitions; six lucid dreamers applied LDP to become more confident in their sport; seven participants used LDP to improve PP with specific goals in mind, like correcting specific routines or the learning of a new movement. The remaining five participants used LDP for one or more of the following reasons: out of curiosity, to have fun, because intense PP or non-lucid sports dreams led to spontaneous LDP dreams, or because they participated in LDP studies (P04). Table 3 depicts motivation

Table 3: Motivation, experience and effects

Code	Motivation ^a : Purposeful usage of LDP	LDP experience ^b	Positive effects of LDP ^c
P02	yes	2	yes
P05	yes	3	yes
P06	yes	1	yes
P07	yes	1	yes
P08	yes	2	yes
P10	yes	1	yes
P11	yes	3	yes
P12	yes	3	yes
P14	yes	1	yes
P15	yes	2	yes
P16	yes	3	yes
P01	no	1	yes
P03	no	1	no
P04	no	2	yes
P09	no	1	no
P13	no	1	no

a) "Yes": named at least one specific application of LDP for their waking life sport(s)

b) 1: 2-13 dreams; 2: 43-95; dreams; 3: >100 dreams

c) "Yes": named at least one positive effect of LDP on their waking life sport(s)

(bivariate), level of LDP experience, and effects of LDP per participant. Literature, lucid dreamers in internet forums and lucid dream researchers/ university lectures inspired the participants to initially try LDP and/ or to use it in specific ways.

Positive effects of lucid dream practice on physical practice

Altogether, 13 of the 16 interviewees named one or more positive effects of LDP. We identified the following four lower order themes of positive effects:

Better performance within a lucid dream (13).* Altogether, 13 participants were or got better during LDP. Seven participants said that their performance during LDP (the whole time) was generally better, easier, or perfect. Three interviewees reported that they generally executed their movements more precisely, more focused, or with better control during LDP: Ten participants felt that they improved *in the course* of LDP. For example, seven martial artists said they got better in techniques and sparring during LDP. P05 learned the basic sequence of juggling during LDP (which also improved her physical performance)*.

Improved performance in physical practice (10).* Altogether, 10 interviewees used LDP successfully to support learning a new movement and/ or to optimize movements. Two participants learned techniques from Taekwondo (P08) and Judo (P12) techniques fast because they practiced a lot in lucid dreams. P12 impressed his teacher when he improved his swimming styles through regular LDP in order to get best marks in his sport studies. He practiced each new style in lucid dreams after learning it in PP and then was much better at it in the next PP lecture*. Eight interviewees named particular movement sequences that they improved through LDP. Here is an example in which a martial artist (P01) practiced a complicated sequence of kicks laterally inverted in a lucid dream. The next time he performed the inverted version of the combination physically, it worked right away*. P10 practiced an Aikido combination in a lucid dream (see *Equipment, partners, and environment*) which helped him to position himself better in the following Aikido class. P12 improved his flip turn in swimming, gymnastic elements (e.g. double flip from the bars), and his running style. Three lucid dreamers said their balance improved through LDP: For example, it helped P11 to balance against the currents in scuba diving.

Enhanced confidence (8). Eight lucid dreamers noticed improved confidence in PP as a consequence of LDP. P12 said that LDP helped his confidence in all his sports because movements become more fluent and precise. P11 became more comfortable with diving because the dreams gave him a feeling of calm and relaxation. P08 said LDP reduced nervousness before a competition (sparring between clubs). Apart from practicing movements, a friend from waking life appeared during LDP and gave her a "pep talk" which significantly improved her confidence. P08 then performed well in the competition although she had to spar against participants with higher belts.

Other positive effects (6).* Altogether, six interviewees reported at least one other positive effect: P11 realized that he took too

much air into his lungs when diving. P06 was motivated to do more PP. For P07 it was positive to carry out movements more consciously. P16 focused on specific aspects of his Taiji practice because of LDP. It also helped with his teaching. P02 said that LDP improved his proprioception and helped him to memorize sequences. P12 reported that his physical flexibility in CrossFit had improved because of LDP*.

Integration of lucid dream practice into physical practice

The interviewees integrated LDP into PP in three different ways: *Lucid dream practice as complementary practice (7)*. Seven participants (all martial artists) complemented their PP by practicing in lucid dreams. P14 especially used LDP when he was training for his black belt. For P15 and P16 the interaction of physical, mental, and lucid dream practice is most effective. P12 complemented PP with LDP with all his sports. For some sports he also used MP, also for preparing LDP.

Lucid dream practice as compensation for physical practice (4). Two interviewees used LDP when guided PP was limited (P15: club closed, P02: missed class). P12 and P16 practiced in lucid dreams when they were injured and could not practice physically (in their dreams they were not injured). P12 said that it helped him “to retain motor activity”, whereas it did not reduce the urge to move when awake. P16 enjoyed the feeling of moving freely.

Lucid dream practice as preparation for specific events (4). Four participants used LDP in at least one way to prepare for an event or varying conditions of PP. P08 prepared herself for belt gradings and a contest, P14 for his black belt grading. P05 had a lucid Yoga dream that reduced her fear of teaching a class in Portuguese by showing her to rely on her body and to explain by demonstrating. As preparation for Rugby matches P12 practiced tackling and repeated tactics on the blackboard.

Important features and possibilities of lucid dream practice

Lucid dreams can be used in specific ways for sports practice and offer various possibilities:

Manipulation of practice conditions, time, and perspective. Five lucid dreamers deliberately manipulated the environment or equipment in lucid dreams – for four of them this worked well most of the time. For example, P12 changed the substances through which he swam to practice with varying resistances. For Judo practice he deliberately created sparring partners of different heights and weights to be prepared for all phenotypes. P11 created the sea to go diving, P08 created an arena for horse riding and a gym for Taekwondo. Four interviewees successfully summoned partners, teachers, or assistants during LDP, e.g. by spinning and changing the scene to one with partners (P16). Sometimes sparring partners appeared because of the dreamer’s intentions to spar. P08 wanted to spar with a partner of her own size and created a copy of herself. P12 summoned professionals who he knew from waking life to give him

advice (especially with gymnastics and swimming). P12 deliberately slowed down or sped up time during LDP. For his swimming practice he sometimes slowed down his movements to improve the main phase of a style and sometimes he swam extremely fast in order to fine-tune fast movements. He also slowed down fights during Rugby practice and manipulated speed in both directions for gymnastic practice. Two interviewees intentionally applied third person perspective to evaluate their movements: P02 once watched himself doing certain Tan Toi positions and thereby took inner notes concerning his viewing direction and arm positions. Although he saw himself from the outside, he could feel himself in his body. P12 regularly changed perspective in various LDP dreams, e.g. in swimming and gymnastics. In Judo LDP dreams he at times took the perspective of his sparring partner.

Most important features of lucid dream practice. When asked what they liked the most about LDP, eight participants named the positive effect on PP. Eight interviewees especially appreciated that during LDP they can do things which are impossible or too risky in wakefulness: doing somersaults and jumps on skis (P04), going downhill very fast on a bike (P06) or skis (P04), or diving down very deep (P11). Seven lucid dreamers liked the new sensations or movements that they learned in LDP. Four participants even gained insights from LDP: For example, P02 said that LDP helped him to understand where the power of motion comes from and P12 had “aha moments” in his LDP dreams concerning movements. To eight participants fun and positive feelings were important. For example, P04 awoke in a positive mood after enjoying skiing in lucid dreams; P10 and P16 had experiences where they felt happy to a point where they were almost ecstatic during LDP–P10 practiced a jump faster and faster until he laughed with joy. Concerning the interviewees’ intentions to use LDP in future, 15 of all 16 interviewees (all but P03) said they can imagine using dreams for sports again. P03 was one of three participants who did not report any positive effects. He only had two LDP dreams, both of which contained problems. He therefore was not convinced of the efficacy of LDP. Eight participants named specific purposes and ideas for their future LDP, while seven of them said they might use it occasionally or when a particular goal comes up in PP.

People who could benefit from lucid dream practice. When asked who could generally benefit from LDP, eleven interviewees answered “everybody” or “every athlete”. Three lucid dreamers said that (especially) professional athletes could use LDP to improve their performance. Furthermore, it was suggested that LDP could be especially effective for children with learning difficulties, for disabled people, as compensation when PP is limited and in rehabilitation. Some said LDP could be useful for athletes with extreme sports (with risk of severe injuries) to become more secure. Two participants said that LDP is more suited for individual sports than for team sports because with team sports there are more variables to control.

Perception of movements

We identified four lower order themes of kinesthetic perception: *Realistic or hyper-realistic (12)**. Altogether, 12 participants described movements in lucid dreams generally as realistic, "hyper-realistic" or "more detailed" than in wakefulness: "You perceive the movement very attentive, very detailed. You are incredibly aware about every single part of that movement" (P09). *More fluent (7)**. Seven lucid dreamers described movements in lucid dreams as "fluent", "fluid", "in a flow", "very soft", "softer" (than in wakefulness), or "smooth".

Less exhaustive (10). Altogether, 10 interviewees experienced movements as requiring less effort, lighter, or less exhausting. P05 also mentioned that she experienced no feeling of overstretching or burning muscles.

Other experiences (9). During LDP, P10 and P05 felt a strong energy flow ("Qi" in Aikido and "Prana" in Yoga); P13, P15, and P16 felt body and mind merge. Four lucid dreamers described LDP movements with positive attributes like "good" (P13) or "peaceful" (P11). Three interviewees described their movements as different from wakefulness in unspecific terms, like feeling "mystic, a bit magical almost" (P15). P09 said that although he felt his muscles move with skiing he could also feel his body lying in bed.

Perception of specific features

The participants described their experiences with gravity, jumps, turns, and balance as follows:

Gravity. Gravity was experienced in three different ways: always normal (4), deviating at times (mostly reduced; 8), or generally reduced (4). Reduced gravity occurred with jumping (also see *Jumps and turns*), skiing (P04), bouldering (P12), and rising movement impulses in Taiji (P16). P10 experienced stronger gravity with squats, P15 with push-ups. For five participants gravity deviations were problematic (see *Problems*).

Jumps and turns. Eight interviewees experienced reduced gravity during jumps (and sometimes turns) in lucid dreams. Three of them found reduced gravity helpful because it gave them more time "to think about the movement during turns" (P01), "correct any imperfections" (P14), or to "remap the kick" (P15) when jumping. P08 felt no dizziness as in wakefulness when spinning, while P07 had difficulties to feel her body when spinning in lucid dreams. P10 described turns in lucid dreams as very intense at times because of a strong acceleration, whereas P06 experienced a reduced g-force during turns. For six participants turns or spins led to a change of scene or awakening (see *Problems*)—interestingly, according to P12 and P14 only spinning around the longitudinal but not the hip axis has that effect.

Balance. Ten lucid dreamers experienced better (6) or even perfect (4) balance during LDP. For example, in contrast to wakefulness, P12 managed to balance on a tight rope and P10 did not have balance problems with a particular jump.

Muscle power. Muscle power was perceived as normal (5), generally stronger (3), generally reduced (2), and varying (5).

Senses

All participants had visual perception during LDP and most of them spontaneously described it as normal or realistic. Here are some examples of visual perception: snow and trees in detail (P09), rising air bubbles when diving (P11), realistic upside-down vision in a headstand (P14). Eight interviewees experienced colors as more vivid or contrasts as stronger. Four lucid dreamers reported that their vision was always or sometimes attenuated because the perceptual focus was mainly on the body. In particular, P01 reported that his vision is "downgraded" to about 20% when he performed complex movements. Regarding sound, except for P06 all participants had auditory experiences during LDP. For P02 and P16 sound was much more vivid than in wakefulness. Examples are the sound of hooves and wind in the ear during horse riding (P08) and the typical "whooshing" of a sweeping spear and the crack when it hits the ground (P02). Three participants reported that their LDP dreams were always complete and realistic regarding all senses. Seven lucid dreamers named examples of touch, temperature, pain, taste, and/or smell during LDP: feeling clothes on skin (P02), feeling wind or airflow (P04, P11, P06), and the warmth of sunshine and vibration of bike wheels (P06). P12 smelt chlorine in a swimming pool and tasted the jelly beans when he fell into a self-created jelly bean pit during gymnastics. P02 felt pain when he was struck hard in sparring, P06 after a bike crash and P08 when she was kicked in sparring. However, for P08 pain was "duller" than it would have been in waking life and P03 hardly felt any pain when he got kicked in lucid dreams.

Equipment, partners, and environment

Usually, participants found or created the equipment and partners they needed for LDP. Eleven interviewees found themselves in unfamiliar, strange, or changing environments (only four of them were disturbed by that, see *Problems*): For example, P01 once had the floor turn into a trampoline while jumping but found it rather funny. The Kung Fu equipment of P02 once became invisible but since he could still feel it, it did not interrupt his practice. When a dream of P10 started out in a swimming pool, he used his environment in a creative way by sparring against a spiral of water which helped him to detect weaknesses in his positions*.

Problems

Some interviewees reported more general problems like not becoming lucid when LDP was planned or waking up too early. However, we focus on specific problems concerning LDP. Ten participants (62.5%) experienced problems during LDP. In the following we describe these problems as well as triggers and reactions.

Movements (7). For seven interviewees movements or exercises did not work out as planned. For example, P03 had heavy limbs and was only able to do Karate in slow motion. In his

Taiji dreams, P16 sometimes experienced physical movement blockades but used them as exercises to strengthen the connection between body and mind.

Equipment, body, or gravity (7). P08 sometimes had walls standing or moving in her way but pushed them away or went into another room. P10 sometimes had trouble to find a suitable stick for the stick form. He only managed to adjust it partly or for a short period. P11 sometimes could not feel his body but managed "to call it back". Five participants had problems with gravity. For example, P12 started floating when bouldering (but not with climbing because he had the rope for orientation). However, four interviewees were able to influence gravity. For example, P16 managed to prevent floating by grounding himself or he used it to his advantage by emphasizing the lightness of Taiji. P15 approached the problem three times with push-ups: after floating at the first attempt and being too heavy at the second, he finally found an "intermediate play" and was able to regulate gravity for a while.

Partners / team mates / games (7). Five lucid dreamers reported dreams in which they could not find sparring partners or interact with them as planned. P03 managed to persuade two dream characters to fight him by telling them that this was a dream and they will be able to do Karate. The horses in P08's dreams sometimes did not cooperate. They also sometimes disappeared visually (she could still feel them) but P08 was able to make them reappear. P12 tried to play Rugby with his team mates in lucid dreams but they instead displayed distracting activities like drinking beer on the field. Although being very experienced, he found it hard to influence that factor. Still, P12 effectively used LDP for his Rugby practice by practicing tackling. Only one other participant (P11) simulated games (football) during LDP and said that always funny things happened but playing soccer in lucid dreams was mostly for fun anyway, not for practice purposes.

Distractions/instability (8). Altogether, eight participants experienced distractions or instability of the dream scene during LDP. Four participants were distracted during or just before LDP, e.g. by dream characters. Two of them lost lucidity as a consequence. In one lucid dream, P10 realized he was naked and got so distracted by trying to create clothes that he never actually started the intended LDP. However, he remembered that experience in a later dream and instead of trying to change things he integrated the present environment in his practice (see *Equipment, partners, and environment*). Six interviewees sometimes had trouble keeping the dream scene stable—in four cases spinning was named as a cause. Consequently, P14 became mindful about that effect and now stabilizes the dream after performing spinning kicks.

Memory (4). Four participants at times had difficulties to remember their martial arts forms.

Preconditions and recommendations

Before presenting more general recommendations, we want to include the only example of a negative experience subse-

quently to LDP: P14 practiced a break dance element ("flare") in a lucid dream. He was familiar with it but had never performed it physically. It worked well in the dream. He woke up directly afterwards and enthusiastically tried to do the flare on the bedroom floor. But because he was physically not prepared for it, he injured his hand. He still considered the experience a "break-through" concerning the understanding of the move.

As preconditions and supporting factors for effective LDP (apart from becoming lucid), the interviewees named discipline, concentration, patience, high motivation, and intense engagement with the sport. However, five lucid dreamers emphasized that it is important to approach LDP with an open mind and to have fun with it. P14 believed that some people may be limited by their expectations: "They think: 'Oh, I can only do my long jump training if I find a long jump pit; but in fact you can just jump'". P12, the most experienced interviewee regarding number and variety of LDP experiences, said that it helps to have a basic idea of the movement you are practicing—the more you are familiar with it, the more realistic the experience and the more effective the practice. P16 recommends starting with LDP as a child to get used to it. He also suggests performing reality checks during PP to facilitate lucidity during sports dreams.

Concerning the combination of different practice methods, three interviewees continuously used a combination of PP, MP, and LDP: Two martial artists (P15, P16) said that for them this is the most effective way of practice. P12, as a coach and natural lucid dreamer with over 1000 LDP experiences from various sports, it was part of his practice routines. He described several examples where he combined the three practice methods. The impressive improvement of his swimming skills (cf. *Improved performance in physical practice*) may have been supported by the fact that as a preparation for LDP, he watched videos showing the recent style in detail. Then knowing what to focus on, he practiced each night until next PP, where he demonstrated much better skills than at the last session, which he then fine-tuned with input from his teacher.

Discussion

The aim of this study was to gain extensive insight on the qualitative aspects of LDP. Before discussing the results, we would like to point out some limitations:

Firstly, since this is an interview study, the results are based on retrospectively reported subjective impressions which provide an extensive description of LDP. Because no objective data (e.g. performance change) were collected, the positive effects which were reported by the majority of the sample, may not have been (all) directly caused by LDP but could be due to generally enhanced confidence or expectations (for empirical data see e.g. Schädlich, 2018). Furthermore, because of the semi-structured nature of the interview the interviewees were automatically aware of the study goal. However, the goal was presented in a neutral way (see *Methods*). Furthermore, we actively asked

about and reported all kinds of LDP, including positive, neutral and negative experiences which should reduce a potential bias towards merely positive aspects.

Secondly, the sample is rather inhomogeneous concerning LDP experience and the interview durations varied strongly (35 - 210 min). We wanted to provide an extensive overview of LDP and therefore included all participants who met the criteria. Therefore, the sample contains participants with different motivations, experiences and evaluations regarding LDP. The varying length of the interviews can be explained by the varying number and variety of LDP experiences (see Table 1) as well as the amount of detail the interviewees provided in their answers.

Thirdly, in contrast to sleep laboratory studies, we cannot ensure that the reported LDP experiences occurred in (REM) sleep and it might be that our participants experienced their lucid dreams in other dream states or even in wakefulness. However, from our experience with dream reports this seems rather implausible except for P09 who reported that he felt his muscles move when skiing in his lucid dream, while feeling his body in bed at the same time. It is possible that P09 was not completely asleep throughout his LDP experience. Even if it did not (completely) occur in (REM) sleep, it still constitutes a form of mental practice during a lucid dream like state. Therefore, we did not exclude the data set.

Fourthly, in interview studies two approaches are possible: either an independent examiner involved or a consensus approach is chosen where experts from the field judge the statements. Because of the extensive and specific data about lucid dream and sport data we decided the second approach: while the first author conducted and transcribed the interviews, the second author was not involved in these processes and viewed the material and analyses with a critical mind.

For these reasons, conclusions must be drawn carefully and need further validation (in addition to previous research). Despite the limitations, the present study demonstrated the multiple possibilities of LDP: Similar to MP in wakefulness LDP can be used to complement PP, as a substitute, when PP is not possible and as a preparation for specific events. Based on the subjective reports of the interviewees, it is possible that LDP can support the learning of new movements and the improvement of familiar movements, even the repetition of strategies in team sports. Furthermore, it appears that LDP can strengthen confidence in PP and help to reduce anxiety. It was also reported that LDP led to specific insights or new experiences which could also facilitate PP. In the following the results are discussed in detail.

Our findings demonstrate that LDP can be applied in various sports as well as for different movements or routines. With this we add to existing examples of LDP from anecdotes (cf. Tholey, 1990) and a qualitative study (Tholey, 1981). However, it is salient that our sample includes many martial artists, although we did not advertise in martial arts related media. Ten interviewees (62.5%) practiced at least one combat sport. How can this correlation be explained? Some interviewees mentioned that

LDP is especially suited for the martial arts because both require discipline and focus and can therefore benefit from each other. Furthermore, martial arts often involve meditation exercises. Lucid dreaming also is associated with mindfulness and meditation (cf. Stumbrys, Erlacher & Malinowski, 2015). Meditation exercises could facilitate lucid dreaming but it is also possible that martial artists take more interest in lucid dreaming because they are interested in meditation and consciousness. Concerning the number LDP experiences, we originally asked about spontaneous and deliberate LDP dreams. However, the interviewees had difficulties with that differentiation because they could have a general goal to practice sports in lucid dreams, without intending it for a particular night. Instead, we differentiated between athletes who practiced with a particular sport-related purpose as opposed to the ones who tried LDP for other reasons (see *Motivation*).

We included reports of being better or improving *during* LDP (independent of their effect on waking life) because they could potentially affect PP and other LDP dreams. However, more interesting for sports practice are the reported direct effects on PP: Altogether, 13 participants reported positive effects of LDP, including performance enhancement, increased confidence, and other positive effects. To evaluate this result, the interviewees' motivations should be adduced: All 11 participants who used LDP purposefully as well as two of the less motivated reported positive outcomes. Hence, motivation appears to have a positive influence on the efficacy of LDP. However, this effect could be moderated by the number of LDP experiences in the sense that higher motivation yields more LDP experiences which heightens the chance of positive effects (see Table 3).

Regarding performance enhancement in particular, 10 interviewees reported improved physical performance as a consequence of LDP. Some examples were quite impressive: P01 reported to have successfully inverted a complicated sequence of kicks in a lucid dream and P12 said that he got a better grade in his swimming exam due to LDP than his teacher thought possible. All seven participants who had intended to specifically improve performance accomplished their goal according to their reports. Although this finding is based on subjective impressions, it is strengthened by previous quantitative research (for overview see Schädlich, 2018). At this point we would like to mention that performing sport in *non-lucid* dreams, i.e. without being aware of the dream state, could, lead to similar effects. Some interviews mentioned that at times they frequently and intensely dreamed about sports practice non-lucidly. However, lucidity has the advantage that one can actively decide to practice and what and how to practice. Dresler et al. (2014) showed that experienced volition in lucid dreams is comparable to wakefulness and higher than in non-lucid dreams. In particular, intention enactment and self-determination were pronounced in lucid dreams compared to non-lucid dreams.

Just as for MP in wakefulness we ask the question: How does LDP affect physical performance? Previous LDP studies support the motor simulation theory by Jeannerod (2001) which proposes that motor imagery (MI) is effective because it activates

similar motor systems in the brain as executed movements and can thus be used for an off-line rehearsal via movement simulation. Using neuroimaging methods, Dresler et al. (2011) showed that dreamed hand movements elicited activation in the sensorimotor cortex. Functional equivalence was also found for peripheral effectors (Erlacher & Schredl, 2008) and relative timing (Erlacher, Schädlich, Stumbrys, & Schredl, 2014) of dreamed movements. However, O'Shea and Moran (2017) point out that the psychological mechanisms underlying MI are not yet fully understood and require further analysis. Existing LDP studies should be included in conceptual considerations and future LDP studies can contribute to fundamental MP questions like the mode of operation of MI.

Another positive and significant effect of LDP is enhanced confidence. Of the 11 interviewees who used LDP purposefully for their sport, eight (72.7%) reported strengthened confidence or reduced nervousness, whereas none of the five less goal-driven participants reported effects of that kind. A particularly interesting example from *Other positive effects* is the one of P12: He was the only one who reported that his flexibility improved after LDP. Studies from MP (in wakefulness) showed that motor imagery (MI) can lead to higher stretching gains (Guillot, Toller, & Collet, 2010; Williams, Odley, & Callaghan, 2004) or higher perceived comfort (Vergeer & Roberts, 2006). However, even in MP studies it is unclear what processes lead to flexibility gains (Kanthack et al., 2017). Future studies could investigate the efficacy of LDP in flexibility tasks and relate them to MI studies.

A very important feature of LDP is the ability to manipulate the dream environment and practice conditions. We demonstrated that this potential can be used to create or vary conditions from PP but it also gives the athlete the chance to practice under conditions that are impossible to do in PP and may be difficult to imagine in waking MP, like performing in slow motion or deliberately changing perspective. Furthermore, the participants emphasized that LDP is also good for doing things that are impossible or too risky in wakefulness. For some lucid dreamers LDP provided insights and new sensations. These effects could be supported by the particularly creative state of mind during sleep and (lucid) dreams: Research has demonstrated a creative potential of REM sleep in general (Cai, Mednick, Harrison, Kanady, & Mednick, 2009), dreams (Schredl & Erlacher, 2007), and lucid dreams in particular (Stumbrys & Daniels, 2010). Last but not least, eight participants particularly appreciated the fun and positive emotions during or after LDP, which shows that LDP can be more than additional practice time. Especially for elite athletes who already practice a lot, LDP can be additional "serious" practice but can also be used to have fun and experiment and thereby could enhance motivation and reduce performance anxiety.

Regarding perception during LDP, our results demonstrate that the overall experience is realistic and can involve all senses. Twelve interviewees (75%) experienced movements as very realistic. This compares to Tholey's (1981) study in which five of six lucid dreamers (83.3%) experienced movements as in wakefulness. For some participants kinesthetic imagery was very

strong: they experienced movements as more detailed than in PP. Furthermore, four participants said that their vision was attenuated because their focus was on their body—for P01 this happened especially for complex movements. Altogether, our results demonstrate a strong kinesthetic perception, which can at times even be the most dominant sense during LDP.

In our study 12 interviewees had experiences with reduced (mostly) or increased gravity, triggered by jumps as well as rising and sinking movements (squats, push-ups). This is in line with Tholey's (1981) finding that his participants also often went into floating when jumping. Also, Erlacher (2007) described examples of reduced and enhanced gravity during squats in lucid dreams. However, of the five interviewees who were at times affected by gravity in our study, four found ways to regulate it. So deviations in gravity do not constitute a general problem in LDP. On the contrary, some participants benefitted from reduced gravity during jumping because it gave them more time to adjust their movements.

Concerning problems, our study shows that LDP does not always work out as expected. However, all but one participant (P03) were not discouraged by them. Furthermore, the lucid dreamers presented examples of how problems can be dealt with. Especially the more experienced lucid dreamers provided some concrete examples and general advice of how to deal with problems or how to avoid them. Some problems seem to arise from the presence of other dream characters, who—in case of combat or team sports—might be required for LDP practice. Experiences with sparring partners are mixed but results show that it is possible to overcome these problems. Although two examples showed that game simulations during LDP do not work well, LDP can still be used to practice movements from team sports (P12: tackling in Rugby; P16: passes and goals in soccer).

Three interviewees regularly used combinations of PP, MP (in wakefulness), and LDP. P12 reported amazing performance gains when practicing different swimming styles in lucid dreams because for one thing he watched videos to prepare his LDP. This "externally guided motor simulation" (Vogt, Di Rienzo, Collet, Collins, & Guillot, 2013, p. 3) is referred to as action observation and can be located on a continuum with motor imagery. This is an example where a particular form of MP, action observation, was used to provide specific input for LDP which led to a great performance gain. MP research has demonstrated, PP combined with MP yields the largest gains in motor performance (cf. Malouin et al., 2013). The combination of PP, MP, and LDP could be a fruitful approach for both research and sports practice, especially for athletes who are lucid frequently.

After demonstrating the effects and potential LDP, we would like to point out that our research questions and results mainly referred to actual practice of movement during lucid dreams. However, the interviewees also had experiences during lucid dreams which improved their sport without (or additionally to) actual rehearsal of movements: P08 was given a helpful "pep talk". P12 repeated Rugby tactics on the black board and summoned teachers for guidance. Others got advice on how to

improve their sport, e.g. by changing their nutrition. These examples open up another field of LDP that is yet to be explored. We are aware that in order to practice sports in lucid dreams, athletes need to induce lucidity first and gain a certain level of dream control. There is a plethora of different techniques which have been tested more or less extensively (for an overview see Stumbrys, Erlacher, Schädlich, & Schredl, 2012). Although to date there is no technique that reliably induces lucidity, research shows that some techniques work better than others, especially cognitive induction techniques such as Mnemonic Induced Lucid Dreaming (MILD; LaBerge, 1980) and Reality Testing (Levitan, 1989). Stumbrys et al. (2012) suggest combining different techniques, including a method called Wake-Back-To-Bed (WBTB; LaBerge, Phillips, & Levitan, 1994). It should be mentioned that many of the interviewees became lucid when dreaming about their sport anyway. Thus, it could be helpful to keep a dream diary and especially record all sport dreams and peculiarities (“dream signs”, cf. LaBerge & Rheingold, 1990) in those that could lead to lucidity. Also, as recommended by P16, performing “reality checks” (e.g. LaBerge & Rheingold, 1990) during PP may facilitate LDP. Concerning the ability to influence the dream, a current study by Stumbrys and Erlacher (2017) suggested that developing mindfulness in wakefulness could help to obtain more control over the dream body and environment.

However, the example of P01, who had only three LDP dreams, shows that one does not have to be very experienced with LDP to have a positive experience and even an effect on waking performance. Based on our results we created a short list of advice for everyone who wants to use LDP or introduce the idea to others:

1. **Motivation:** Chose a sport or movement you want to improve in some way but do not set your goals too high for the beginning.
2. **Fun:** Approach LDP with curiosity and have fun experimenting with it
3. **Familiarity:** You should be somewhat familiar with the movement you want to practice
4. **Focus:** Stay focused on what you wanted to do. If something does not work the way you intended, you can try to adjust it. If it does not work, practice anyway. Unfamiliar or bizarre practice conditions could actually lead to new experiences or insights.
5. **Mindfulness:** Always be careful when physically performing a movement after LDP, especially if the movement is unfamiliar or when there is a risk of injury.
6. **Exchange:** Connect with others who use LDP or are interested in it, for example, in lucid dream or sport forums, to get inspiration or inspire others. It also helps with motivation.

In conclusion, our study demonstrated the great potential of LDP. Motivated athletes with a high lucid dream frequency could include LDP in their practice routine and combine it with

PP and possibly MP. Also athletes who are not lucid frequently could benefit from LDP because even single LDP experiences can lead to positive effects. Furthermore, LDP not only has a potential for improving sports but can be used for rehabilitation as well as activities that require specific motor skills, like playing musical instruments or surgery. LDP as a specific way of MP has not received much attention in research so far. The present study elucidates the necessity to include LDP in general MP research and discussions. We also want to encourage researchers to further investigate the benefits of LDP both qualitatively, quantitatively, and in various areas of applications.

Funding

The authors have no funding or support to report.

Competing Interests

The authors have declared that no competing interests exist.

Data Availability Statement

All relevant data are within the paper.

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Supplemental Material: Additional quotes by sections

Positive effects of lucid dream practice on physical practice

Better performance within a lucid dream (13).

P02 *There is less hesitation. If I throw out a punch or a kick it doesn't wobble as much. It's all very tight and very focused.*

P05 *That was the dream where it clicked, it was the click! And it's physical. And you know the kinesthetic feeling is just so strong in lucid dreams that your body remembers it – you remember, when you wake up.*

Positive effects of lucid dream practice on physical practice

Improved performance in physical practice (10).

P12 *Every Monday I tried to do the main phase of a new swimming style and it did not work. Then I did it three nights in lucid dreams. Each Thursday I asked my teacher to take a look and she was astonished how I had accomplished that learning step from Monday to Thursday. I was able to do the main phase we had learned on Monday perfectly on Thursday.*

P01 *I got the idea to perform that particular sequence of kicks: first a spinning crescent kick and while you are in the air, you jump again and perform a second spinning kick. In waking life I was only able to do that starting with my left foot, so that I did the jumping kick with my right foot. During the dream I did it that way two or three times and was pretty impressed because the jumps were higher and lasted longer. And then I got the idea to do it laterally inverted, which did not work at all the first three times. Then I thought about it for 5 to 10 seconds: about the exact sequence of movements and how I can invert it. And after two attempts it worked! I performed it another two, three times and then woke up.*

Positive effects of lucid dream practice on physical practice

Other positive effects (6).

P12 *In CrossFit I often use a 20 kg Olympic barbell. In the dream I know exactly how much 20 kg are and I can move the barbell just slow and fast as in reality. I try to maximize the movement. With squats, for example, I try to get my bottom lower or to shift my knee more forward, backwards, or to the side. For that I try to extend the natural 'range of motion' but only so that the brain realizes that this is possible. I want to become more flexible.*

Perception of movements

Realistic or hyper-realistic (12).

P05 *You have this really deep kinesthetic sense and proprioceptive sense, you know, you can feel exactly what your limbs and muscles are doing.*

Perception of movements

More fluent (7).

P02 *And generally I feel like everything is kind of aligned. Often in waking life it feels like different parts of my body are trying to kind of fight each other but in dreams it often feels like everything is working together very well without me having to think about it as much.*

Equipment, partners, and environment

P10 *The water now is my sparring partner. I practice Irimi Nage, entering with Atemi [entering throw and strike technique in Aikido]. In front of me is a filigree water spiral which reacts to each of my movements, even every little shade. It shows me directly when I am doing something wrong. I practice it a few times. Once it works perfectly – an exhilarating feeling! I am in harmony with the water, feel exactly how the technique works*