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Neural Effects of the Repetitions Process during the Athletic Training Program on the Hippocampus and Prefrontal Cortex of the Brain

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Abstract:
The medial temporal lobe (MTL) plays a key role in learning, memory, spatial navigation, emotion, and social behavior. Neuroimaging of declarative memory is not an endeavor divorced from psychology but, instead, is another path through which a more complete understanding of memory has emerged in physical training. There are only three ways that information can move from short-term memory to long-term memory: urgency, repetition, or association. Urgency, releasing stress hormones, creates a powerful wash of chemicals that strengthens the connection between neurons, or synapses. Urgency also determines how and where the brain encodes the information into long-term memory [15] [28].

Repetition is the most familiar learning; every athlete has memorized skills or tactic process by repeating them and some have improved basketball free-throw shooting or combat skills practice. Repetition creates long-term memory by eliciting or enacting strong chemical interactions at the synapse of the neuron, where neurons connect to other neurons. Repetition makes the strongest learning, and most learning implicit and explicit relies on repetition. It is also why it is so hard to change behavior of the elite athletes: the new behavior must be repeated for so long, and the old behavior must be kept in check.

Association is the ability for a piece of information or part of skill to tap into a neural connection that already exists. All three of these methods affect the neuron or synapse level in similar ways for long term memory. The stimulation from urgency, repetition or association will create new proteins inside the neuron-- at the level of the synapse a self-perpetuating protein is created which the connection keeps going between neurons. This is a long-lasting self-perpetuating protein, and it gets strengthened with repetition. In addition to this self-perpetuating cycle, the neuron, through the protein process also creates a new synaptic terminal growth—to increase the connection—it adds another branch on its tree to strengthen and increase the network. So, repetition grows the brain's neural network to perfecting the skills [33] [102].

The improvement of noninvasive neuroimaging techniques, especially magnetic resonance imaging, has increased the knowledge about this region and its involvement in cognitive functions and behavior in healthy subjects and patients with various neuropsychiatric and neurodegenerative disorders. The improvement of noninvasive neuroimaging techniques, especially magnetic resonance imaging, has increased knowledge about this region and its involvement in cognitive functions and behavior in healthy subjects and patients with various neuropsychiatric and neurodegenerative disorders, as one of the crucial principles in athletic training. While they use these terms abstractly and superficially during the training process, this article aims to awaken awareness of the basic neural aspects so that appropriate techniques can be used for high achievement.

Keywords: (Repetition, Memory, Neuroimaging techniques, Hippocampus)

Introduction:

Repetition is a well-documented trigger for memory formation—the more times something is repeated, the better it is achieved. However, the brain's machinery is more complicated than that. The researches show that the effects of individual repeated events interact in more nuanced ways and have distinct roles in working to form long-term memories-neurons can sense not just repetition, but also the order of repeated experiences and can use that information to discriminate between different patterns of these events in building the athletic memories. Neurons can tell the difference between two events in escalating order of intensity and those same two events in the opposite order, forming a memory only if the intensity increases over time [34] [35] [36].

When athlete performs multiple resistance exercise sets, the maintenance of a target number of repetitions has been shown to be a key factor that stimulates the development and expression of different characteristics such as maximal strength, hypertrophy, and localized muscular endurance [2] [3] [11] [66] [108]. Overall, there is an inverse relationship between the load used and the repetition maximum (RM) [3] [6] however, the RM achievable with a given load has been shown to vary between resistance exercises that involve different muscle groups, ranges of motion, and neural recruitment patterns [3] [40]. Furthermore, several studies have indicated that when multiple RM sets are performed during a resistance exercise session, significant reductions in repetitions occur between the first set and subsequent sets, a trend demonstrated for resistance exercises that involved upper and lower body muscle groups and even when instituting up to 5-minute rest intervals between consecutive sets [55] [76] [77] [88].

A key factor that determines the ability to maintain repetitions is the recovery time between sets. Several studies have demonstrated that longer rest intervals allowed for significantly greater repetitions and volume versus shorter rest intervals, when the load was held constant over multiple sets; this was demonstrated for single exercises and multiple exercises as in a typical resistance training session [55] [66] [76] [77] [78] [88] [94] [108]. Because resistance exercise prescriptions designed for hypertrophy and localized muscular endurance commonly involve moderate to high repetitions in combination with shorter rest intervals. Load reductions might be necessary, especially to maintain target repetitions conducive to these training goals Repeated exercise improves retention, which is combined by increased cell proliferation and survival in the hippocampus [2] [3] [11] [50] [64] [72] [73] [74] [102] [103]. Repeated exercise presentation during training and using a semantic encoding task increase the accuracy of subsequent skill retrieval. Previous neuroimaging studies have shown that successful word retrieval depends on the recruitment of the hippocampus, whereas the retrieval effort is linked to the activation of prefrontal cortex modules [29]. Repetition of a specific movement invokes muscle memory. In the same vein, athlete can train for a specific sport or goal by monitoring his weights and repetition in relation to his tennis swing, layup form, or swim stroke. Over time, as he repeats; his performance during each set will improve. Building strength requires consistency and repetition for the body to adapt to resistance and the load that put on it. Plus, by repeating training, the athlete be able to track his progress [40] [78] [79] [95] [108] [109]. Repetition doesn't mean everything's the same, it may be cycling through the same strength-training sessions, but that doesn't mean doing the exact same thing during all the workouts. The body can still be challenged during a repeat doing by arriving what's called a progressive overload. [42] [94] [95].

The repetitions refer to the number of times that a certain movement or, exercise can be repeated, and it may depend on the load being lifted. For its rule more repetitions must be with a low or moderate load, it is essential to promote endurance. But what is the power of repetition exercise? Repetition can be powerful in three ways. First, as we repeat something, like sports move or a piano piece, we move toward mastering it. Second, we can accomplish a giant task with frequent small actions toward the goal. Third, repetition creates habits [29] [61].

Training scientists confirm that to master something, "spend 10.000 hours" on its practice. While that notion has been questioned recently, there's still much truth to it; create habits through repetition [54]. It's through repetition that we rewire our brains. Doing something over and over, no matter how small, has a huge power. In regard to the Power of Habit, after repeating something repeatedly wanting to do into a habit that limited willpower can be used somewhere else [21] [29].

As the daily or weekly act becomes a habit, the athlete has unleashed a life-changing power [29]. Those patterns always remain inside the brain. By the same rule, though, if we learn to create new neurological routines that overpower those behaviors if it can take control of the habit loop, it can force those bad tendencies into the background. And once someone creates a new pattern, studies have demonstrated, going for a jog or ignoring the doughnuts becomes as automatic as any other habit. Because repetition of the same thought or physical action develops into a habit which, repeated frequently enough, becomes an automatic reflex [29]. Perform the same exercises a few times enable athletes to be mastering the movement pattern and creating a mind-body connection that reinforces the basic structure of an exercise and lets them springboard forward with their goals [37]. Neuroimaging of declarative memory is not an endeavor divorced from psychology but, instead, is another path through which a more complete understanding of memory has emerged [15].

By repeating similar exercises throughout programming time, the athlete notices a huge difference in his strength and lean muscle; and will see the shape and definition of his body increase. If he compares the number of reps he can complete or the weight he is lifting in an exercise to when he first started, it is clear how much stronger he has become. By repeating movement patterns, the body becomes more efficient at moving that way; the muscles grow stronger and more capable. Beside the athlete can train harder at the same exercises. [8] [9] [12] [13] [14] [19] [22] [52] [54].

Neuroscience now understands why repetition improves performance. With neuroscience, we now know that "practice makes permanent." The best analogy for neurons is a power cord, and inside the cord, we have a copper wire that transmits the electricity - in the brain; this wire is called the axon. Outside the power cord, we have a rubber wrap that insulates the wire so that outside forces cannot affect the transmission of electricity this is called myelin. The better insulated the axon, the faster and more reliably the signal can travel from one neuron to the next. We now understand that practice and repetition mean muscle memory increase the myelin so that the signal can move more rapidly and consistently. The other benefit of strong myelin is that when athlete is stressed, the synapses are "protected" from the stressor hormones, which means the brain will execute the most "protected" habit [34].

To stimulate further adaptation toward specific training goals, progressive resistance training protocols are necessary. The optimal characteristics of strength-specific programs include the use of concentric, eccentric, and isometric muscle action methods and the performance of bilateral and unilateral single and multiple joint exercises [2] [3]. There are different types of reps based on the specific fitness goals: high resistance, low repetition, and low resistance, high repetition. The American College of Sports Medicine recommends 12–15 reps of a light load to increase endurance, 8–10 reps of a moderate load to aid hypertrophy, and 3-5 reps of a heavy load to build strength. The weight itself will differ based on the individual goal that, just make sure that his weight selection is appropriate for muscle fatigue [74] [92]. Repetition matters because it can hasten and deepen the engagement process. "Repetition is the first principle of all teaching" [2] [10] [11] [2] [92] [94].

Additional benefits of repetition include taking time to truly focus on what athletes are doing no more going through the motions. Performing the same exercise repeatedly allows one to fine-tune his movements and master the basics. The results can be applied to weekly bench press workouts that undulate between heavy (80% 1RM) and light (50% 1RM) intensities. When the training goal is maximal strength development, three minutes of rest should be taken between sets to avoid significant declines in repetitions. The ability to sustain repetitions while keeping the intensity constant may result in a higher training volume and consequently greater gains in muscular strength [109]. The results of previous studies suggest that upper-body exercises involving similar muscle groups and neural recruitment patterns are negatively affected -in terms of repetition-performance when performed at the end against the beginning of a session, and the reduction in repetition performance is greater when using a one minute against three minute rest interval between sets [55] [92] [93] [95] [97] [98] [99].

Besides, the motor memory repetition of a specific movement invokes muscle memory, also, some workouts are better than others. Because following a repetition training program makes it easy to identify when athlete is in a mental slump versus when he is having a bad training day [92]. Listening to the body as knowing when the athlete needs to rest and when he can push harder. Sports training scientists confirm that “repetition is the key to learning.” Everyone needs to constantly review the material for his brain to absorb the information [10] [26] [40] [44] [59] [92][98] [99].

Repetition may seem boring and sometimes exhausting, but practical experience confirms that practice makes perfect and shows how beneficial this training method can be, especially in the fitness world. A repetition training program benefits the mind and body in various ways. A repetition, or “rep,” is one complete exercise movement, while a “set” is a group of consecutive reps. So, three sets of fifteen reps look like 15 bicep curls, rest for 30 seconds, 15 bicep curls, rest for 30 seconds, 15 bicep curls. When we think of reps, it is usually about weightlifting; however, reps are also part of cardio training [10] [11] [78] [86] [92]. In training science, the essence of repetition is the mother of all skills. It is so important to make what initially might seem complicated into something that is second nature to the athlete. When we are talking about a strike, a kick, or a throw, each movement it contains is taught, practiced, and practiced again and again until the body learns to perform each action without thinking about it [44] [85].

Aim and Problem:

Coaches and trainers in sports training have overlooked the neurological aspects of exercise repetition within training programs, if repetition merely involves mental strain on the body's vital organs. They have not considered the neurological processes occurring in various areas of the brain. This article aims to furnish them with essential information regarding the brain's adaptations. Through repeated training and exercises, it aims to enhance training for greater performance.

From another point of view, when an action is repeated, the moves involved are indelibly imprinted on the brain. This is referred to as muscle memory [88], and the more the action is performed, the more permanent the moves become, which means person will be able to perform them quicker and more precisely with each passing day. Muscle memory is also beneficial in sports because it allows athletes to complete complex movements without thinking about each individual step. This allows the athlete to focus on the game tactics where their competition memory is indispensable to ongoing motor learning and that it makes further learning [10] [59] [60] [61] [62] [107].

Repetition improves speed of movement required specially for combat and fighting sports. A move that is practiced to this degree almost becomes a reflex action. As the method is burned into the neural pathways of the athlete, it becomes not only automatic but lightning-fast, also. [42] [50] [57] [79] [99]. Loading recommendations for resistance training are typically prescribed along what has come to be known as the "repetition continuum" which proposes that the number of repetitions performed at a given magnitude of load will result in specific adaptations [74].

Another important benefit of repetition is that it promotes good economic form, even at faster speeds. This economy of motion is achieved by teaching the muscles involved to move in the right position and at the correct angles. It begins with holding the right starting position and moving to the next with no wasted energy. This is referred to in some martial arts circles as a ‘no mind’ movement, as it’s something that the body just knows how to do. Power is something that is also improved with constant repetition of the same actions. However, as the benefits of repetition increase, muscles become stronger, giving more power as well as speed [34].

Neural Literature Analysis of Repetition:

Neural analysis of the literature for repetition in athletic training declared that repetition creates the strongest learning—and most learning; repetition is most critically mediated by cortical regions in the left posterior temporal-parietal cortex; repetition and auditory-verbal short-term memory (AVSTM), which are mediated by partially overlapping networks; repetition and AVSTM deficits can be observed in different types of aphasia [5]. Repetition has several effects on memory and memorization, including improved memory retrieval, verbal overshadowing, and more. It also ensures that information is encoded correctly in the brain. The studies of VLSM analyses showed that the left posterior temporal-parietal cortex, not the actuate fasciculus, was most critical for repetition as well as for AVSTM [1] [2] [3] [5] [6] [49].

When stimuli are learned by repetition, they are remembered better and retained for a longer time. However, current findings are lacking as to whether the medial temporal lobe (MTL) and cortical regions are involved in the learning effect when athletes retrieve associative memory and whether their activations differentially change over time due to learning experience. Comparing to learning once, learning six times led to stronger activation in the hippocampus but weaker activation in the perirhinal cortex as well as the anterior ventrolateral prefrontal cortex [113]. In recognition memory tests, feelings of familiarity with stimuli vary in strength. Increasing levels of felt familiarity should modulate activity in brain structures that mediate familiarity memory [56].

The ventromedial prefrontal cortex generates pre-stimulus theta coherence desynchronization [30]. When stimuli are learned by repetition, they are remembered better and retained for a longer time. However, current findings are lacking as to whether the medial temporal lobe (MTL) and cortical regions are involved in the learning effect when subjects retrieve associative memory, and whether their activations differentially change over time due to learning experience [113]. In addition, hippocampal activation was positively correlated with that of the Para hippocampal place area (PPA) and negatively correlated with that of the VLPFC when the Trailed 6 group was compared to the Trail 1 group. The hippocampal activation decreased over time after T1 but remained stable after T6. These results clarified how the hippocampus and cortical regions interacted to support associative memory after different learning experiences [4] [5] [6] [8] [9] [108] [112] [114]. Also, other study findings suggest that a contextual fear memory acquired in a single session under stronger learning parameters remains dependent on the hippocampus [48]. And the volumes of the entorhinal and perirhinal cortices were unaffected by age. While there were no differences between men and women in the volumes of any of the three cortices [41].

The Memory consolidation refers to the transformation over time of experience-dependent internal representations and their neurobiological underpinnings. The process is assumed to be embodied in synaptic and cellular modifications at brain circuits in which the memory is initially encoded and to proceed by recurrent reactivations [20]. Planning-related activities, wherein subjects reinstate details outlining the nature of desired remembrances, should occur in response to contextual memory cues even before retrieval probes are available [17].

After repetition learning, memory performance can be enhanced and maintained for a long time. Less is known, however, about the brain mechanisms for the learning effect. Repetition suppression and repetition enhancement during memory encoding and retrieval are two phenomena that were reported in previous studies. During encoding, multiple learning leads to decreased activation in stimulus-related cortical regions and the hippocampus when compared to learning once. The suppression of repetition in the hippocampus is confirmed when single stimuli and stimulus associations are repeatedly presented. Studies that focus on implicit retrieval suggest that hippocampal activation increases when persons retrieve repeated items versus new items by explicit strategy, but those studies did not directly manipulate retrieval processes to explore the role of the hippocampus in the learning effect [10] [108] [113] [114].

Only a few studies explored the effect of repetition learning on explicit retrieval but obtained inconsistent results, especially in the hippocampus. However, Reagh et al. [72] showed that hippocampal activation was weaker during retrieval after multiple rounds of learning than after learning once. It is one difference between the studies was that recall and recognition tasks were used separately [55] [71] [72] [113].

But theories on memory consolidation have different predictions for the effect of repetitive learning on hippocampus activation over time. According to the Standard Consolidation Theory (SCT) [81] repeated memories are more likely to become independent of the hippocampus and rely on the neocortex, such as posterior perceptual regions [20] [66] [102]. Although the poor learners' retrieval performance declined dramatically from the day to the month lag, the good learners maintained a high retrieval performance, which distinguishes them as good memory consolidators [8].

Thus, with the passage of time, hippocampus activation should decrease more quickly after repetition learning (vs. learning the stimuli once), diminishing the learning effect in the hippocampus at longer intervals. On the other hand, based on the Multiple Trace Theory (MTT) and Transformation Trace Theory TTT), the nature of memory representation determines whether memories depend on the hippocampus for their duration or whether they depend on the neocortex with time [51] [58] [59] [64] [65] [113] [114]. Specifically, because repetition enhances the relational associations between items [113], if the associated pairs are remembered, those relational associations are preserved, predicting relatively sustained hippocampal activation across time [22] [23].

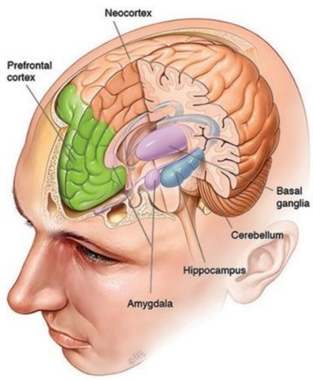
Episodic encoding more than the sum of its parts [89] [100]. Sleep promotes the consolidation of declarative as well as procedural and emotional memories in a wide variety of tasks. Sleep improves, preferentially, the consolidation of memories that were encoded explicitly and are behaviorally relevant to the individual [16]. In addition to the hippocampus, there is an interesting in whether repetition learning modulates the connectivity between the hippocampus and other regions over time. Previous studies have confirmed the interaction between the hippocampus and neocortical regions during explicit retrieval when stimuli are learned once [58] [62]. There are strong anatomical connections between the hippocampus and the prefrontal cortex (PFC) [82], and between the hippocampus and posterior cortical regions. The PFC is involved in searching, monitoring, inhibition, and evaluation of relevant information at retrieval, and the posterior regions are involved in processing stimulus-related information [23] [24] [25] [64] [82] [83].

However, these processes may vary depending on the learning experience. Compared to learning once, repetition learning requires fewer executive controls [25] [63] and more stimulus-related processing, so it is possible that the interaction between the hippocampus and PFC decreases and the interaction between the hippocampus and stimulus-related regions increases, but empirical evidence is lacking [64]. One way to study the formation of neural representations is to examine brain activity in response to repeated stimulus input [6] [67] [86] [91] [96]. The brain is a complex organ that controls thought, memory, emotion, touch, motor skills, vision, breathing, temperature, hunger, and every other process that regulates our body. Together, the brain and spinal cord that extend from it make up the central nervous system [31] [32] [33] [39] [63].

In humans and animals, mental schemas can store information within an associative framework that enables rapid and efficient assimilation of new information. Using a hippocampus-dependent paired-associate task, some reports now reveal the anterior cingulated cortex is part of a neocortical network of schema storage with NMDA receptor-mediated transmission critical for information updating, and AMPA receptor-mediated transmission required for the expression and updating of stored information [105] [106]. The standard model of system-level consolidation posits that the hippocampus is part of a retrieval network for recent memories. According to this theory, the memories are gradually transferred to neocortical circuits with consolidation [90]. The phenomenon of temporally graded retrograde amnesia (loss of information acquired before the onset of amnesia) suggests that the hippocampus and possibly other medial temporal lobe structures have a time-limited role in memory. Three experiments made use of fMRI to assess activity in the hippocampus region [87]. Also, the medial temporal lobe (MTL) plays a key role in learning, memory, spatial navigation, emotion, and social behavior. The improvement of noninvasive neuroimaging techniques, especially magnetic resonance imaging, has increased the knowledge about this region and its involvement in cognitive functions and behavior in healthy subjects and patients with various neuropsychiatric and neurodegenerative disorders [28].

For explicit memories, which are about events that happened to person (episodic), as well as general facts and information (semantic), there are three important areas of the brain: the hippocampus, the neocortex, and the amygdala Implicit memories, such as motor memories, rely on the basal ganglia and cerebellum [63] [107]. Some studies indicated that although the hippocampus is crucial for laying down memories, it is not the site of permanent memory storage and isn't needed for motor memories. These studies were revolutionary because they showed that multiple types of memory existed.

Figure (1). Memories Stores



We now know that rather than relying on the hippocampus, implicit motor learning occurs in other brain areas- the basal ganglia and cerebellum [63] [64] [80]. The neocortex is the largest part of the cerebral cortex, the sheet of neural tissue that forms the outside surface of the brain and is distinctive in higher mammals for its wrinkly appearance. In humans, the neocortex is involved in higher functions such as sensory perception, the generation of motor commands, spatial reasoning, and language. Over time, information from certain memories that are temporarily stored in the hippocampus can be transferred to the neocortex as general knowledge. The neocortex is part of the human brain's cerebral cortex, where higher cognitive functioning is thought to originate. Due to the natural grooves and ridges in the brain, the neocortex is comprised of four main lobes with specific functions [7].

Conscious memory for a new experience is initially dependent on information stored in both the hippocampus and neocortex. Systems consolidation is the process by which the hippocampus guides the reorganization of the information stored in the neocortex such that it eventually becomes independent of the hippocampus [84] [85] [86] [87]. Memory encoding occurs rapidly, but the consolidation of memory in the neocortex has long been held to be a more gradual process. In experiments using a hippocampal-dependent paired-associate task for rats, the memory of flavor-place associations became persistent over time as a putative neocortical schema gradually developed. Schemas also played a causal role in the creation of lasting associative memory representations during one-trial learning. The concept of neocortical schemas may unite psychological accounts of knowledge structures with neurobiological theories of system memory consolidation [97].

Conclusion:

Recent findings and reviews suggest that repetition effects interact with episodic memory processes that are putatively supported by the hippocampus. Thus, the formation or refinement of episodic memories may be related to a modulating signal from the hippocampus to the neocortex, which leads to sparser or more extended stimulus representations (repetition suppression or enhancement), depending on the type of stimulus and the brain site. This framework suggests that hippocampus activity during the initial presentation of a stimulus correlates with the magnitude of repetition effects [47] [80].

Repeated information is often perceived as more truthful than new information. This finding is known as the illusory truth effect, and it is typically thought to occur because repetition increases processing fluency. Because fluency and truth are frequently correlated in the real world, people learn to use processing fluency as a marker for truthfulness. Although the illusory truth effect is a robust phenomenon, almost all studies examining it have used three or fewer repetitions [53]. Also, repetition of specific exercise training increased hippocampus volume by 2%, effectively reversing age-related loss in volume by one to two years. We also demonstrate that increased hippocampus volume is associated with greater serum levels of brain-derived neurotrophic factor (BDNF) that is one of the most distributed and extensively studied neurotrophins in the mammalian brain, and as mediator of neurogenesis in the dentate gyrus [26]. Brain-derived neurotrophic factor (BDNF) is one of the most distributed and extensively studied neurotrophins in the mammalian brain.

Over time and with repeated experience, memories undergo a reorganization process involving different neuronal networks, known as system consolidation. According to standard consolidation theory (SCT), the traditional view is that episodic and semantic memories initially rely on the hippocampus [110]. Memory consolidation refers to the transformation over time of experience-based internal representations and their neurobiological foundations. This process is thought to involve synaptic and cellular changes in brain circuits where the memory was first encoded and to progress through recurrent reactivations [20].

Conscious memory for a new experience is initially dependent on information stored in both the hippocampus and neocortex. The hippocampus shrinks in late adulthood, leading to impaired memory and an increased risk for dementia. Hippocampal and medial temporal lobe volumes are larger in higher-fit adults, and physical activity training increases hippocampus perfusion. The previous studies are suggesting that fitness protects against volume loss. These theoretically important findings indicate that aerobic exercise training is effective at reversing hippocampus volume loss in late adulthood, which is accompanied by improved memory function [26]. Also, short-term adherence to physical activity in older adults improves psychomotor processing abilities and is associated with greater brain activation. It is not known whether these associations are also significant for longer-term adherence to moderate-intensity activities [12] [26] [27] [28] [29] [71].

On top of that, deterioration of the hippocampus precedes and leads to memory impairment in late adulthood [25] [26] [27]. Strategies to fight hippocampus loss and protect against the development of memory impairment have become an important topic in recent years from both scientific and public health perspectives. Physical activity, such as aerobic exercise, has emerged as a promising low-cost treatment to improve neurocognitive function that is accessible to most adults and is not plagued by intolerable side effects often found with pharmaceutical treatments [26]. Exercise enhances learning and improves retention, which is accompanied by increased cell proliferation and survival in the hippocampus of rodents [101] [102] [103] [104] [105] [111] [112] [113].

The studies also, found that aerobic exercise selectively increased the volume of the anterior hippocampus, which included the dentate gyrus, where cell proliferation occurs [11] [47] [55]. The CA1 is the first region in the hippocampal circuit, from which a major output pathway goes to layer V of the entorhinal cortex. plays a role in input integration, and the subiculum contributes to memory retrieval in addition to its role in learning and memory, the hippocampal formation has been implicated in other functions. As s well as the subiculum and CA1 subfields but had a minimal effect on the volume of the posterior section. Cells in the anterior hippocampus mediate the acquisition of spatial memory [94] and show more age-related atrophy compared with the tail of the hippocampus [108]. The selective effect of aerobic exercise on the anterior hippocampus was confirmed by a significant time-group-region interaction for both the left and right [11] [27] [47] [55] [105]. It is important for the educational community to become more aware of the benefits of distributed practice [29].

The pooled results of randomized trials showed that older people who underwent physical exercise presented a statistically significant increase in cerebral blood velocity. This result indicates that physical exercise is important to help maintain cerebral health in older adults [62] [83] [88] [97]. Beside Significant increases in brain volume, in both gray and white matter regions, were found as a function of fitness training for the older adults who participated in the aerobic fitness training but not for the older adults who participated in the stretching and toning (nonaerobic) control group. As predicted, no significant changes in either gray or white matter volume were detected for our younger participants [14]. Persistent engagement in physical Activity may have beneficial effects on psychomotor processing speed and brain activation, even for moderate levels and even when started late in life. Future studies are warranted to assess whether these beneficial effects are explained by delayed neuronal degeneration and/or new neurogenesis [71].

Surprisingly, hippocampal volume was reduced in the control group, suggesting that physical fitness protects against volume loss. These theoretically important findings suggest that aerobic exercise training is effective in reversing hippocampal volume loss in late adulthood, which is accompanied by improved memory function [26], [27] [28]. There is robust evidence that the medial temporal lobes play an important role in episodic memory, but over time, hippocampus contributions to retrieval may be diminished. However, it is unclear whether such changes are related to the ability to retrieve contextual information and whether they are common across all medial temporal regions. It has been suggested that episodic and semantic long-term memory systems interact during retrieval [18] [38] [45] [46] [69]. Also, high-quality repetitions of greater volumes of physical activity are associated with sparing of prefrontal and temporal brain regions, which reduces the risk for cognitive impairment [98], hippocampus and medial temporal lobe volumes are larger in higher-fit older adults [26] [27] [77] [78], and larger hippocampus volumes mediate improvements in spatial memory. Besides that, repetitive exercises are accompanied by increased cell proliferation and survival in the hippocampus. [8] [9] [11] [64] [72] [73] [102] [103]. Interestingly aerobic exercise is a promising low-cost treatment for improving neurocognitive function that is affordable for most adults and does not suffer from the side effects often found with pharmaceutical therapies. [26] [27] [50] [102].

Recommendations:

Based on the above scientific, functional, and physiological analyses of the repetitive process and its processing in the brain, the following recommendations can be reached:

1. It's important to note that the effects of athletic repetition can depend on specific properties of neural representations, such as their specificity. Specificity refers to how accurately a particular piece of content is represented, and it's crucial to achieve this accuracy when implementing a skilled technique in athletic training programs.
2. Regular exercise with controlled repetitions is essential for trained athletes and the public because it promotes neurogenesis in the hippocampus, improves its function, improves cognition, and regulates mood.
3. Strategies to fight hippocampal loss and protect against the development of memory impairment have become an important topic in recent years from both scientific and sporting perspectives.
4. There is a need for prospective innovation evaluation, standardized devices, and technical tests to evaluate whether exercise training increases hippocampal volume and improves spatial memorability.
5. Providing opportunities for athletes and the public to participate in sporting activities has demonstrated that physical activity, such as aerobic exercise, is a promising low-cost treatment for improving neurocognitive function that is affordable for most adults and does not suffer from the side effects often found with pharmaceutical treatments.
6. Increased health education and medical awareness should be given to controlled repetitive exercises as they improve memory, accompanied by increased cell proliferation and survival in the hippocampus.
7. Regarding older adults, athletes must practice aerobic exercise and repeated high-quality repetitions to increase gray and white matter volume in the prefrontal cortex and improve the functioning of key nodes in the executive control network.
8. Recommend performing high-quality repetitions. While greater volumes of physical activity are associated with sparing of prefrontal and temporal brain regions, which reduces the risk for cognitive impairment, hippocampal and medial temporal lobe volumes are larger in higher-fit older adults, and larger hippocampal volumes mediate improvements in spatial memory.
9. Attention should be paid to increasing repetitive exercise training to achieve an increase in cerebral blood volume and hippocampal perfusion.
10. It is urgently needed to enhance path physiological research concerning athletes with Alzheimer's disease because of repetitive head blows in combat and fighting sports.
11. The theoretically important findings indicate that aerobic exercise training is effective at reversing hippocampal volume loss in late adulthood, which is accompanied by improved memory function
12. At last, it is worth noting that, fortunately, exercising is not expensive, enables every person to do it, and is not restricted to a specific place of performance.

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