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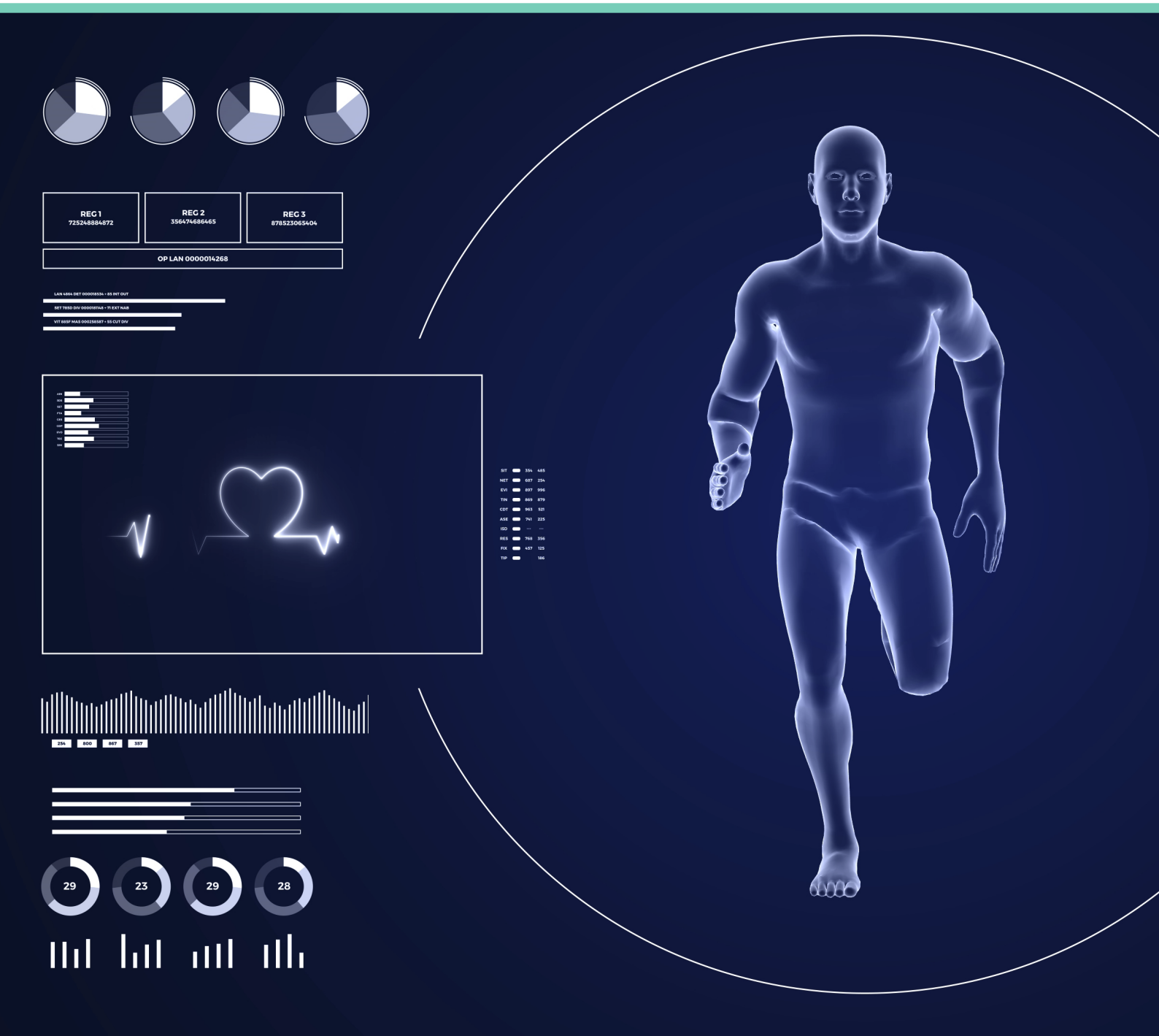

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SUMARIO / SUMMARY / RESUMO

Editorial

The studies published in this issue cover different areas within physical activity and sport. MLS Sport Research aims to publish original research and review articles in basic, applied, and methodological areas that contribute to progress in the field of Physical Activity and Sport Sciences.

The first article deals with the "Degree of self-compassion in injured high-performance athletes." It has been observed that self-compassion improves adaptive coping, well-being, and reduces anxiety in stressful situations. The present study sought to see if there were significant differences in the level of self-compassion in high-performance athletes with or without injury at different times of the season. The results collected in this research were neither conclusive nor significant, so it would be recommended to carry out similar future studies with a larger sample, in contexts of sports injury and with a psychological intervention in between.

The second study is entitled "Oxygen saturation and lactate test with cyclists." This study aims to determine whether the Humon Hex device used to measure SmO2 can be used in an equivalent way to the lactate test. The objective is to compare blood lactate concentration and SmO2 measurement to predict lactate threshold power during the performance of a progressive stress test in trained cyclists.

The next of the studies deals with "Monitoring of training and competition loads in women's soccer: a case study." The monitoring of loads is investigated to diagnose the recovery and optimization of athletes. The objective was to show the evolution of the loads of female field players in different microstructures (ME) by observing how environmental fluctuations influence the elaboration and execution of these and to provide reliable and valid, low-cost, economic, monitoring tools. 23 participants aged 22±3 years from the 1st Catalan Regional Division (Group A) were observed during the 2018-2019 season.

The next of the studies is entitled "Impact of resistance training in child and youth population." The objective of this review was to know the influence that strength training has on the child and youth population, in addition to looking for possible risks or benefits that may be caused by training this physical fitness. A systematic review of intervention studies on the impact of strength training in subjects aged between 6 and 18 years was carried out. The studies used in this review were identified through the PubMed database, selecting those written in English or Spanish from 2010 to the present.

The journal issue is completed with an article on "Intensity, frequency and duration of physical activity during the pandemic in Ecuador." The present research aims to define the intensity, frequency, and duration of physical activity practiced by the respondents in order to determine possible repercussions on integral health in the medium and long term. The instrument used was the International Physical Activity Questionnaire (IPAQ), short version. As a conclusion, a probable relationship could be established between confinement and a decrease in physical activity; and between confinement and the number of hours that respondents have remained seated.

Dr. Álvaro Velarde Sotres and Dr. Felipe García Pinillos
Editores Jefe / Editors in chief / Editores Chefe

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DEGREE OF SELF-COMPASSION IN INJURED HIGH PERFORMANCE ATHLETES

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Abstract. It has been observed how self-compassion improves adaptive coping, well-being and reduces anxiety in situations of stress. The present study tried to see if there were significant differences in the level of self-compassion in high-performance athletes with or without injury at different times of the season. With a sample composed of 79 athletes from different disciplines, it was carried out through the Scale of Self-compassion SCS in Spanish, summarized from 12 articles (García-Campayo, Navarro, Andrés, Mortero, López and Piva, 2014). The results collected in this research were not conclusive or significant, so it would be advisable for future studies with a larger sample, in contexts of sports injury and with a psychological intervention of the environment.

Keywords: Athletes, high performance, injuries, self-compassion.

GRADO DE AUTOCOMPASIÓN EN DEPORTISTAS DE ALTO RENDIMIENTO LESIONADOS

Resumen. Se ha observado como la autocompasión mejora el afrontamiento adaptativo, bienestar y reduce la ansiedad en situaciones de estrés. El presente estudio trató de ver si existían diferencias significativas en el nivel de autocompasión en deportistas de alto rendimiento con o sin lesión en momentos diferentes de la temporada. Con una muestra compuesta de 79 deportistas de diferentes disciplinas, se llevo a cabo a través de la Escala de Autocompasión SCS en español resumida de 12 items (Garcia-Campayo, Navarro, Andrés, Mortero, López, & Piva, 2014). Los resultados recogidos en esta investigación no fueron concluyentes ni significativos, por lo que se recomendaría efectuar estudios futuros similares con una mayor muestra, en contextos de lesión deportiva y con una intervención psicológica de por medio.

Palabras clave: Deportistas, alto rendimiento, lesiones, autocompasión.

Introduction

The psychology of physical activity and sport is a specialized area of psychology that, in recent years, has grown rapidly as a supporting science in all areas of physical culture. This area of psychology employs mental preparation techniques such as

motivation, anxiety management, attention control, concentration development, personality management, and self-confidence. Similarly, it seeks, through some group strategies such as leadership, the development of communication and group cohesion, and increase the sporting potential of athletes. On the other hand, applied psychology supports the processes of initiation and sports performance in basic sports training, as well as in the management of eating disorders, injuries, and disability (Sánchez Jiménez & León Ariza, 2012).

The following is a brief review of the significant role of psychology in high performance sport, together with the study of self-compassion in recent years, both at a more general (clinical) level and at a more specific level, in sport, which is where we will focus our research.

Psychology in high performance sport

It has long been known that the performance and sporting results of an athlete or team is multifactorial. That is, its success or failure depends on the computation of physical, technical, tactical, and psychological capabilities (Williams C. y., 2001). Here the role of the sport psychologist is understood as a technician in psychology at the service of the coaching staff (coach, physical trainer...) although the coach is the main psychological manager (responsible) of the athlete and/or team. As such, the sports psychologist must participate in the general preparation of the athlete, together with the other technicians and specialists (doctor, nutritionist...). The work of the sports psychologist in grassroots sport, in general, tends to have greater job stability (medium / long term projects) (Garcia-Naveira, 2010). On the other hand, in professional and semi-professional sport, the immediate goal is to achieve results and beat others. For this, the objectives are focused on the psychological well-being of the athlete and the increase of sporting performance, starting from the basic premise that the psychological aspect should definitely be considered as another important part of the overall preparation of the athlete, as one more element that must interact properly with the physical, technical, and tactical aspect (Buceta J., 1998).

We cannot forget the origin of sport psychology, which is psychology itself, and how its base is fixed in clinical psychology, bringing to this new field more meaning. Thus we know how certain disorders (anxiety-stress, obsessive-compulsive disorder...) can be associated with sporting demands in high performance (maximum demand, strict sporting discipline...), and the solution requires an in-depth knowledge of the context in which it takes place, being present at that moment of the season in which it occurs (immediacy), assessing whether or not it interferes in the activity and in their personal life and making an assessment both from the psychological dimension and in its sporting dimension (Ezquerro, 2002).

To conclude this section, we will summarize the main actions that the sports psychologist can have within the high performance: activities aimed at the athlete, psychological evaluation, intervention, gender differences, attention to foreign athletes, training, athlete retreats, aggression in sport, education in values, activities aimed at the team, activities aimed at coaches, work with the family, collaboration with the medical area, collaboration with sports management, and work with referees (Garcia-Naveira, 2010).

Self-pity

The concept of self-compassion has existed in Eastern philosophical thought for centuries but is relatively new in the West. It involves treating oneself with kindness, recognizing what we have in common with other human beings, and being aware of one's own deficits or negative aspects. In other words, the self-compassionate person seeks happiness and well-being while fully accepting his or her limitations. In the West, the term self-pity is associated with feeling sorry for oneself, instead of assuming with us the compassion that we would feel towards other people, in seeing ourselves with kind eyes, or even taking care of ourselves. In painful situations, some people exercise self-punishment instead of understanding, which would lead to self-pity. The concept of self-compassion was defined by Kristin Neff, a psychologist at the University of Texas, Austin, who locates it as a concept derived from Buddhist psychology, conceptualizing it in recent years in terms and in a way that allows its scientific investigation.

Self-compassion is a key psychological construct for evaluating clinical outcomes in mindfulness-based interventions. Subsequently, several studies have appeared showing the relationship of self-compassion with psychological health. First, it is important to distinguish between self-compassion and self-esteem. Self-esteem refers to the degree to which we value ourselves and is often based on comparisons with others. In contrast, self-compassion, which is not based on positive judgments or evaluations, is how we relate to ourselves. People who feel self-compassion feel it because they are human beings, not because they are special or tend to feel better than others in order to feel good about themselves, offering more emotional stability as opposed to self-esteem and being a better predictor of happiness (Neff & Vonk, Self-compassion versus global self-esteem two different ways of relaxing to oneself, 2004). Thus self-compassion (as opposed to self-esteem) helps protect against anxiety when faced with ego threat in a controlled environment and increases in self-compassion elapsed over a one-month interval have been associated with greater psychological well-being (Neff K. D., 2007). Related to positive psychological functioning and personality traits, self-compassion was found to have a significant positive association with measures of happiness, optimism, positive affect, wisdom, personal initiative, curiosity and exploration, agreeableness, extroversion, and conscientiousness. In addition, it also had a significant negative association with negative affect and neuroticism. Self-compassion predicted significant variance in positive psychological health beyond that attributable to personality (Neff K. D., 2007). On the other hand, its influence on pain has been proven. In a sample of patients with chronic pain, self-compassion was associated with greater acceptance of pain (Costa & Pinto-Gouveia, 2011). Another study conducted in patients with chronic pain, found that self-compassion is an important indicator to explain variability in pain, and that high levels of self-compassion are associated with better psychological functioning in these patients (Wren, et al., 2011).Self-compassion is positively related to indices of health and psychological well-being (Van Dam, Sheppard, Forsyth, & Earleywine, 2011). Thus, not surprisingly, people who score high on self-compassion also tend to score low on neocriticism and depression, and higher on life satisfaction and subjective well-being (Leary, Tate, Adams, Allen, & Hancock, 2007) (Neff K. D., 2007) (Neff K. D., 2007) (Neff K. D., 2007).

Drawing on the writings of Buddhist scholars, Kristin Neff has divided self-compassion into three main interacting components, each of which has two parts. They are self-kindness, as an alternative to self-criticism; the feeling of belonging to a common humanity, as an alternative to the feeling of isolation; and mindfulness, as an alternative to over-identification with one's own thoughts or emotions (Neff K. , Self-compassion:

An alternative conceptualization of a healthy attitude toward oneself, 2003). The central aspect of self-compassion, treating oneself kindly when things go wrong, has been observed through public demonstrations, taking time off to give oneself an emotional break or even through simply having thoughts of kindness and forgiveness (Gilbert, Clarke, Kemple, Miles, & Irons, 2004).

Self-kindness (instead of self-criticism)

Self-kindness is the tendency to view oneself in a positive, benevolent, and understanding way, rather than harshly criticizing or judging oneself. It is especially emphasized when a person fails or has problems. An example is thinking, "When I'm going through a difficult time, I get the care, attention, and affection I need." Self-compassionate people recognize that being imperfect, failing, and experiencing life's difficulties are inevitable. Therefore, when they fail at something or face painful experiences, they maintain a kind attitude toward themselves, rather than becoming angry or self-critical. Kindness to oneself means accepting that one cannot always be or get what one wants, and if that reality is denied or we resist accepting it, our suffering increases in the form of stress, frustration, and self-criticism. On the other hand, when we accept it graciously, we experience greater emotional equanimity. Thus, one's own shortcomings and deficits are treated sympathetically, and the emotional tone of the inner language (of thoughts and self-talk, referring to oneself) is one of warmth and support. Instead of criticizing, angering, and self-condemning ourselves for our failures or limitations, we calmly accept the fact that we are imperfect. Similarly, when external circumstances are difficult, self-compassion allows us to offer ourselves as much support and comfort as possible (NeffK. Self-compassion: An alternative conceptualization of a healthy attitude toward oneself, 2003).

Shared humanity (instead of a feeling of isolation)

This component implies having a sense of common humanity, which recognizes that imperfection is typical of the human experience, and which allows one not to feel odd or different from others when facing one's own failures or limitations. Neff believes that the frustration of not being or not having what we want is often accompanied by an unhealthy sense of being inadequate or different, as if one is the only one who suffers or makes mistakes. But the reality is that we all have faults and deficits and suffer in some way, as we are all mortal, vulnerable, and imperfect. Therefore, self-compassion includes recognizing that suffering and feelings of inadequacy are part of the shared human experience, something we all experience. It also means recognizing that one's thoughts, feelings, and actions are influenced by factors that are not dependent on oneself, such as genes, interaction with caregivers in childhood, culture, lived situations, and the behavior and expectations of others. Being aware of these allows us to be more understanding of our failures. Acknowledging our interdependence helps us to take our failures and difficulties in a more self-compassionate way; for example, by thinking, "When I feel inadequate, I remember that this is a feeling that most people have experienced at times." The sense of common humanity, central to self-compassion, involves recognizing that all people fail, make mistakes, and feel inadequate at times. Imperfection is assumed to be part of the human condition, so personal weaknesses are seen in a broader perspective. Difficult life circumstances are also framed as shared human experience, so that when one experiences suffering, one still feels connected to others. Self-compassion makes it easier for us to maintain a similar attitude toward others. Compassion leads us to see them as fallible people, to accept them as such, and to wish them to develop the best of themselves and to be free of any suffering. It is an open attitude in which the boundary

between self and others is softened, considering that all human beings are worthy of respect and compassion. The feeling of shared humanity constitutes a healthy alternative to competitive social comparisons, which are automatically carried out in fragile self-esteem (NeffK. Self-compassion: An alternative conceptualization of a healthy attitude toward oneself, 2003).

Mindfulness (rather than identifying with thoughts or emotions)

Also called mindfulness, it involves experiencing the present moment without being carried away by the tendency to over-identify with one's emotions. It involves a receptive state of mind in which one observes one's thoughts and feelings as they are, without trying to suppress or deny them but without magnifying them. Such a balanced attitude can be facilitated by relating one's own experiences to those of others who experience similar emotions; by seeing one's own current experience from a broader perspective; or by becoming accustomed to observing one's own thoughts and emotions with openness and clarity, as is done in mindfulness practice. Some characteristics of mindfulness, according to Neff, are the following:

- Observe one's thoughts and emotions with openness and clarity, as they appear in consciousness.
- Don't over-identify with them, lest they trap or drag us down.
- Being aware of the experience of the present moment, in a clear and balanced way, without ignoring the things we don't like about ourselves, others or life, and without exaggerating them or focusing too much on them.
- Recognize when we feel bad about something, since many times we don't detect it because we don't pay attention to ourselves, or because we are too busy judging ourselves or trying to solve problems.
- Adopting a broad perspective of one's own experience, in order to consider it more objectively and not be dragged down by one's own discomfort, something that can lead to an obsessive fixation on negative thoughts and emotions, and prevent a clear vision of oneself and one's problems (Neff K. Self-compassion: An alternative conceptualization of a healthy attitude toward oneself, 2003).

Self-compassion in athletes

Previous literature indicates that self-compassion improves adaptive coping and well-being by reducing anxiety in stress-provoking situations. Stress has been linked to a number of adverse consequences, including an increased risk of sports injuries. The history of stressors, coping resources, and personality factors will moderate the stress response to a potentially stressful situation and subsequently alter susceptibility to injury (Williams & Andersen, 1998). Research already conducted with self-compassion intervention on negative cognitive states in female athletes demonstrated the effectiveness of self-compassion intervention in managing self-criticism, rumination, and preoccupation with errors over a 5-week period. Asserting that fostering a self-compassionate state of mind is a potential resource for female athletes dealing with negative events in sport (Mosewich, 2013). Another later study but within the same field, measured measures of self-compassion, self-esteem, and narcissism, as well as reactions, thoughts, and emotions in response to hypothetical and withdrawn scenarios. Subsequently and with prior intervention, the results were favorable for those athletes with higher levels of self-compassion. They generally responded more healthily to emotionally difficult and recalled hypothetical situations in sport than their less compassionate counterparts (Reis, 2015).

Self-compassion had not yet been studied in the context of injury history and as a possible moderator of the association of stress and sports injury. This latest research showed that self-compassion may buffer the experience of somatic anxiety and worry, reducing the engagement of avoidance-focused coping strategies. Notably, there were no significant findings related to self-compassion and injury reduction, i.e., self-compassion did not significantly contribute to injury frequency (Huysmans& Clement, 2017).

Method

Sample

We had a heterogeneous sample of convenience, formed by 79 high performance athletes from the community of Cantabria belonging to different sports [rugby = 26 (32.9%), basketball = 3 (3.8%), handball = 11 (13.9%), football = 10 (12.7%), badminton = 7 (8.9%), volleyball = 12 (15.2%), and athletics = 10 (12.7%)]. Of these, 67 were male (84.8%) and 12 were female (15.2%). The age range ranged from 10 to 53 years (M = 22.09, SD = 7.35).

The study was conducted in two phases. A first phase where all subjects were injury free at the beginning of the season (September 2017), and a second phase where only 7 athletes of the total (8.8%) had been injured halfway through the season (February 2018).

Measuring instruments

The reported internal consistency indices of the different scales (Cronbach's α) correspond to the data of the present investigation (See APPENDIX I).

Self-Compassion Scale (SCS)

The brief version was applied (Neff K. D., The Development and Validation of a Scale to Measure Self-Compassion, 2003) adapted to Spanish (Garcia-Campayo, Navarro, Andrés, Mortero, López, & Piva, 2014), 5-point Likert type (1 = Almost Never; 5 = Almost Always) composed of 12 items and which assesses the degree of self-compassion through three scales, both in the first measurement in September (α_S = .59) and in the second measurement mid-season in February (α_F=.68). The first scale was self-kindness or kindness to self (α_S=.44, α_F=.40, example of the item: "I try to be understanding and patient with those aspects of my personality that I don't like"), common humanity (α_S=.16, α_F=.26, example of the item: "I try to see my defects as part of the human condition") and mindfulness (α_S=.42, α_F=.49, example of the item: "When something painful happens to me, I try to keep a balanced view of the situation"). On the other hand, we find its opposite scales whose items must be reversed in the final result: self-judgment (example of the item: "I disapprove of my own shortcomings and am very critical of them"), isolation (example of the item: "When I am low in mood, I tend to think that most people are probably happier than I am"), and over-identification (example of the item: "When I fail at something important to me, I am consumed by feelings of ineffectiveness") (Neff K. D., The Development and Validation of a Scale to Measure Self-Compassion, 2003).

Results

We tried to find significant differences between the first and second measurements with respect to the level of self-compassion. To do so, we compared the means of the scales of the two independent samples in both the first and second measurements in injured and non-injured athletes. After that, we could not determine that there were significant statistical differences in any of the scales from the first to the second measurement (See Table 1 and Table 2). Due to the lack of differences between the scales, what was expected to be the second part of this research was not included in this study. This second part consisted of semi-structured interviews carried out for injured athletes. The objective of this was to relate the mindfulness scale with various psychological variables studied and influenced to date with a higher risk of injury (level of attention, level of activation, among others) (Buceta J. M., 1996).

Table 1

Differences between groups with and without pretest injury

	S n=72		S/C n=7			
	M	SD	M	SD	t.	Sig.
Self-kindness	3.25	.67	3.42	.57	.673	.503
Shared Humanity	3.45	.57	3.57	.67	.491	.625
Mindfulness	3.53	.63	4.00	.50	1.90	.061

Note: Pre, refers to the first measurement taken in September 2017; S, refers to the group of athletes who remained uninjured throughout the research; S/C, refers to athletes who came in uninjured and ended up with injury.

Table 2

Differences between groups with and without post-test injury

	S n=72		S/C n=7			
	M	SD	M	SD	t.	Sig.
Self-kindness	3.34	.65	3.57	.44	.905	.368
Shared Humanity	3.37	.61	3.53	.71	.647	.520
Mindfulness	3.52	.68	3.78	.79	.963	.338

Note: Post, refers to the second measurement taken in February 2018; S, refers to the group of athletes who remained uninjured throughout the research; S/C, refers to the athletes who came in uninjured and ended up with injury.

Discussion and conclusions

The aim of this study has been to deepen the knowledge of self-compassion in the sports field, with the purpose of finding significant differences in these scales of self-compassion in high performance athletes with and without injury. A second part of the research was also developed in order to relate self-compassion with other psychological variables studied to date that are influential in the suffering of sports injuries (such as the level of attention or activation, among others), through semi-structured interviews for those injured athletes.

The results obtained have not been conclusive to determine that self-compassion has a significant influence on the suffering of injuries. The small sample has proven to be of little relevance to draw conclusive data and the reliability of the instrument has shown a low internal consistency, as in other previous research with injured high performance athletes (Huysmans& Clement, 2017). Therefore, these even results in these investigations could cast doubt that this scale is a reliable and valid tool to analyze the level of self-compassion in these sport contexts. Similarly, no significant differences were found in these levels of self-compassion in high-performance athletes with and without injury in both investigations.

Despite the data collected, there are many investigations that corroborate the reliable suitability of this instrument to clinical contexts (Gálvez Galve, 2012) and even the author herself re-evaluated the instrument a few years ago (Neff K., 2015). In the clinical setting, previous studies carried out with athletes have obtained significant results in the levels of self-compassion as long as an intervention was carried out with the athletes prior to the last measurement (Neff K. D., 2007) (Mosewich, 2013) (Reis, 2015). Given that these results have not been equally satisfactory in the last study carried out with this

same scale (Huysmans & Clement, 2017), it could then be said that the significant differences between samples have not been perceived since an evaluation of the sample has been made and an intervention has not been carried out.

The results obtained through this research once again highlight the fundamental role of psychological intervention with injured athletes and the importance of continuing research into other concepts that have been little studied to date but which are relevant, as is being demonstrated with self-pity. As Robert Johnson, Jungian analyst, says, people are more reluctant to accept the noble aspects of our shadow than to hide its dark parts. That is, it seems to be more disturbing to discover that you have a deep nobility of character than to admit that you are a slob. Self-compassion, far from seeking pity, requires a balanced approach to negative experiences, it is a form of acceptance but rather than accepting a feeling or a thought, self-compassion is the acceptance of the person to whom a painful situation is happening. It is a process of the heart letting go of effort. (Komfield, 2010)

For future research, it would be appropriate an intervention within the sporting environment as have been carried out in other studies with athletes through the program "Mindfulness and Stress Reduction" (MBSR) to explore self-compassion and empathy in the context of mindfulness-based stress reduction (Birnie, 2010); or the program "Mindfulness and Self-Compassion" (MSC) with 8-week intervention, where it has been observed that with maintenance for 6 more months, it was still possible to see significant differences and results after a year in their participants (Neff & Christopher, Program, A Pilot Study and Randomized Controlled Trial of the Mindful Self-Compassion, 2013).

Finally, this study carried out with high performance athletes has had several limitations throughout the 8 months that the research has lasted. The first, derived from the small size of the sample, which may not have been sufficiently representative and therefore could not be extrapolated to larger populations. Not being homogeneous in gender, nor in athletes without injury and with injury (only 8.8% of the athletes with injury) may also have limited the results obtained.

Secondly, the fact that it was not possible to intervene in the athletes due to lack of time and means reduced the possibility of conclusive results in the study. Due to these results, we had to discard a qualitative analysis carried out thanks to a semi-structured interview with the injured athletes created exclusively for this research and where we wanted to deepen in the relationship between the increased level of activation, the reduced focus of attention with differences in the mindfulness scale and a higher risk of injury (Buceta J. M., 1996). Given the lack of significant and disparate results between the sample of injured and non-injured athletes in the mindfulness scale, it was discarded to incorporate the data from the interviews to this research. The possibility of using another scale of mindfulness with greater reliability and being able to see differences between the two measurements through the Five Facet Mindfulness Questionnaire (FFMQ) was considered (Baer, 2008). Finally it was discarded, since previous studies conducted to date with this questionnaire, had only been conclusive in clinical settings and with differentiated samples of meditation practitioners and non-meditation patients.

Although athletes are likely to cope with nerves, their responses will vary depending on situational factors and individual differences. Self-compassion may be an alternative way for athletes to respond to stressors in a healthy manner. Existing literature suggests that in response to a situation that elicits novel and therefore stressful situations, self-compassion can be used to enhance adaptive coping and well-being and reduce anxiety (Allen & Leary, 2010) . Therefore, in response to a stress-provoking situation, a

compassionate athlete would demonstrate understanding rather than self-judgment and would be able to recognize that stress is part of the human and sporting experience and would not have to resign to the situation. Self-compassion would allow the athlete to create a mental distance from the stressor so that he or she does not over-identify with the experience. In this way, self-compassion would serve as a defense mechanism against suffering from stress and sports injuries.

However, the application of self-compassion in sport is a relatively new area of research which has not yet been thoroughly and comprehensively studied in the injury setting, so further research in this area and in relation to injured and non-injured athletes would be recommended, including a greater diversity of sample within the wide range of sports.

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OXYGEN SATURATION AND LACTATE TEST WITH CYCLISTS

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Abstract. This study aims to determine if the Humon Hex device used to measure SmO2 can be used as an equivalent to the lactate test. Studying whether the potency of the lactate threshold can be established by changes in SmO2. The objective is to compare the blood lactate concentration and the SmO2 measurement to predict the lactate threshold power during the performance of a progressive exercise test in trained cyclists. During the power increases, it is observed that the% SmO2 decreases, and the Lactate concentration increases. Through Pearson's correlation analysis, a strong inverse correlation is evidenced between the variables studied. It is observed that SmO2, both at the basal level and at the lactate threshold, presents a wide dispersion of its values that limits its usefulness, and we were unable to find a standard absolute threshold value for all the subjects in the sample. Comparing the threshold lactate power estimated by the lactate concentration in the blood, and the algorithm of the Humon Hex software gives an average difference of 13w ± 18.5, and an average time difference of 87" ± 27.5. Although the n of the sample is low, this data is promising to apply the Humon Hex as an indirect estimation tool of the lactate threshold of daily training.

Keywords: training, intensity, lactate, lactate threshold, SmO2

SATURACIÓN DE OXÍGENO Y TEST DE LACTATO EN CICLISTAS

Resumen. En este estudio se pretende determinar si el dispositivo Humon Hex empleado para medir la SmO2, puede usarse en forma equivalente al test de lactato. Estudiando si la potencia del umbral de lactato se puede establecer mediante los cambios de la SmO2. El objetivo es comparar la concentración de lactato en sangre, y la medida de SmO2 para predecir la potencia de umbral de lactato durante la ejecución de una prueba de esfuerzo progresivo en ciclistas entrenados. Durante los incrementos de potencia se observa que disminuye el % SmO2, y la concentración de Lactato aumenta. A través del análisis de correlación de Pearson se evidencia una correlación inversa fuerte entre las variables estudiadas. Se observa que la SmO2 tanto a nivel basal como en el umbral de lactato, presenta una amplia dispersión de sus valores que limita su utilidad, y no se logra encontrar un valor umbral

absoluto estándar para todos los sujetos de la muestra. Al comparar la potencia umbral de lactato estimada por la concentración de lactato en sangre, y el algoritmo del software del Humon Hex da una diferencia promedio de 13w ± 18,5, y una diferencia de tiempo promedio de 87´´± 27,5. Si bien el n de la muestra es bajo estos datos son prometedores para aplicar el Humon Hex como una herramienta de estimación indirecta del umbral del lactato del entrenamiento diario.

Palabras clave*:* entrenamiento, intensidad, lactato, umbral de lactato, SmO2

Introduction

In the planning of endurance training, it is necessary to know the training zones, that is, the intensity of exercise according to the objective of the session. Blood lactate concentration is an indirect measure used for intensity control (Brooks, 2020; Rodriguez et al., 2019), it is a reference parameter used to determine the intensity levels in training planning. The measurement of muscle oxygen saturation (SmO2) is a new method that through the technique of near-infrared spectroscopy (NIRS) non-invasively determines changes in tissue oxygenation in athletes performing incremental exercise (Racinais et al., 2014). While the assessment of the lactate test indicates systemic changes and is invasive, with muscle oxygen saturation we obtain a continuous and non-invasive assessment of what happens in the muscle against the effort.

The present study aims to answer whether a NIRS device that measures SmO2 can be used in an equivalent way to the lactate test in the indirect determination of intensity. The relevance of the topic is given that the device used to measure muscle oxygen saturation is portable and non-invasive compared to the lactate test. In order to validate the use of an indirect measurement tool to estimate the lactate threshold and thus identify the training zones, determine the intensity levels that serve as inputs in the planning and dosing of loads. The objective is to compare the blood lactate concentration and the SmO2 measurement to predict the lactate threshold power during the execution of a progressive effort test in trained cyclists. During the execution of the test, the % of SmO2 of the vastus externus and the lactate concentration are recorded. The relationship between muscular oxygen saturation with power and lactate concentration with power is analyzed during the test. The theoretical support of the work is addressed in the theoretical framework; chapter 1: refers to cycling and science in the development of science and technology applied to the efficiency of sports performance; chapter 2: sports training specifically oriented to cycling, and the intensity as one of the significant variables in terms of the organization of stimuli in terms of performance objectives; chapter 3: metabolism, processes, and substrates; chapter 4: defines lactic acid, lactate, lactate test, and lactate threshold as an indicator of aerobic and anaerobic transition zones; chapter 5: muscle oxygen saturation and near infrared spectroscopy (NIRS), and the Humon Hex device as the new portable technology (NIRS) that in this study is used to indirectly determine lactate threshold, according to muscle oxygen levels.

Near-Infrared Spectroscopy NIRS

Near-infrared spectroscopy (NIRS) is a technology used in different fields of study such as agriculture, cardiology, neurology, and sports sciences, among others (Pino Ortega et al., 2019). Near-infrared spectroscopy (NIRS) oxygenation measurements reflect O2 supply and utilization in muscle exercise and can improve the detection of a critical exercise threshold (Van Der Zwaard et al., 2016). NIRS is used in sport to measure muscle oxygenation during physical exercise in real time using infrared beams, light emitters, or laser diodes with wavelengths in

the range of 700-850nm2 and NIRS detectors (Ferrari et al., 2011). It was first commercialized in 1996 (Hitachi Co. Ltd.) basically to display brain activity in neurology (Ferrari & Quaresima, 2012). Oxygen is transported by hemoglobin through the body and varies depending on the intensity of physical activity by a decrease in pH and increase in temperature. SmO2 variations during the course of exercise are related to the relationship between O2 availability in blood and its use in muscles. With NIRS it is possible to estimate SmO2, i.e. the ratio of oxy-hemoglobin to total hemoglobin in the blood, expressed as a percentage.

NIRS Advantages

The data obtained, through a non-invasive technique, are on the kinetics of oxygen saturation in muscle using light emissions and NIRS detectors, which can reach a depth of 4-5 cm deep. Oxygen (O2) is transported in the blood by hemoglobin and by myoglobin in the muscle, and during exercise its levels vary before an intense stimulus oxygen decreases. SmO2 changes depend on the balance between the oxygen available in the blood and its use by the muscle, the % of SmO2 is the ratio of oxy-hemoglobin to total hemoglobin in the blood. With NIRS it is possible to monitor changes in muscle tissue O2 reserves and O2 availability at the cellular level. It is a technique that takes into account the fact that biological tissues are transparent to infrared light and can be used to measure up to 8 cm depth. And considering that the absorption of light in muscle tissue depends on the degree of oxygenation, then the different levels of absorption will indicate the % of SmO2 during exercise. They are portable devices, which can be used during training with real-time monitoring via wireless technology. According to the publication, Monitoring muscles to improve athletic training of the Massachusetts Institute of Technology news office (Winn, 2018), the Humon Hex arises as an idea of a class project at the Sloan School of Management of the Massachusetts Institute of Technology of two students, Daniel Wiese, student of technology and innovation while pursuing his doctorate in mechanical engineering, and Alessandro Babini, a master's degree in management studies. They received support from the Martin Trust Center for MIT Entrepreneurship. Near-infrared spectroscopy, the core technology behind Hex, is a lightweight device that attaches to a user's thigh to determine oxygen levels in muscles by emitting light into muscle tissue and measuring its absorption. That information is then transmitted to a user's phone, smartwatch, or laptop via Bluetooth or ANT+ technology and displayed in a simple graph along with personalized information. As athletes train, the graph shows them whether their muscles are consuming oxygen at a higher rate than they're being supplied, which tells them whether their current pace is sustainable. In another Fast Company article (Schulte, 2019): Why NBA athletes are using this device to improve their training, it is noted that the success of the Hex is that it tracks muscle performance in real time. When oxygen enters the blood through the lungs, it binds to hemoglobin in the cells and turns bright red. After the oxygen is transported and used by the muscles, the blood turns dark blue-red. The Hex interprets how well the muscles are working based on the color of the blood. Moxzones is the app to measure SmO2, distance, time, pace, speed, and much more in real time The app is available for smartphone and Android, and it works in conjunction with the web platform. The hexagon illuminates the muscle with red and infrared light, then four evenly spaced sensors read the amount of light passing through the muscle and how much is absorbed. Bright red, oxygenated blood will absorb more infrared light and allow red light to pass through, while oxygen-poor, blue-red blood will absorb more red light and allow infrared light to pass through. The Hex measures oxygen levels in an athlete's thigh muscle over the course of a workout and, using proprietary software, generates colored graphs showing whether the user's muscles are consuming oxygen at a sustainable (green), unsustainable (red), borderline (orange), or low (blue) rate.

Lactate

Most evidence suggests that lactate is an important intermediate in numerous metabolic processes, a particularly mobile fuel for aerobic metabolism and perhaps a mediator of the redox state between various compartments both within and between cells (Brooks, 2020). Traditionally lactate measurement in training is used to manage different intensities in sports planning, the relationship between lactate and exercise has been the subject of study for over 200 years. Changes in exercise intensity and duration significantly affect lactate concentration (San-Millán, 2020). The production of lactate does not cause acidosis but delays it; every time ATP is broken down into ADP and P(i), a proton is released. When the ATP demand of muscle contraction is met by mitochondrial respiration, there is no accumulation of protons in the cell, as the mitochondria use the protons for oxidative phosphorylation and to maintain the proton gradient in the intermembrane space. Only when exercise intensity increases beyond steady state is there a need for increased reliance on ATP regeneration from glycolysis and the phosphagen system. ATP supplied from these non-mitochondrial sources and ultimately used to drive muscle contraction increases proton release and causes the acidosis of intense exercise. It is with the production of lactate that the NAD(+) needed in phase 2 of glycolysis is achieved. Increased lactate production therefore coincides with cellular acidosis and remains a good indirect marker of the cellular metabolic conditions that induce metabolic acidosis. Lactate acts by reducing acidity because it consumes H+ when very high intensities are developed and maintained over time. H+ production exceeds the buffering system producing a decrease in pH. Stored intramuscular glycogen provides energy, during intense exercise, to phosphorylate ADP during anaerobic glycolysis; in the absence of oxygen supply to accept hydrogen, pyruvate is converted to lactate. Lactate is formed even under resting conditions which is removed by cardiac and skeletal muscles, but when production exceeds the rate of removal under intense exercise its production accumulates. Blood lactate begins to increase exponentially around 55% of maximal aerobic capacity for an untrained healthy person. The increase in lactate concentration during exercise is relative tissue hypoxia (oxygen deprivation). With oxygen deprivation, anaerobic glycolysis meets energy needs and the release of hydrogen ions begin to exceed their oxidation in the respiratory chain. Traditionally, lactate measurement in training is used to manage different intensities in sports planning, the relationship between lactate and exercise has been the subject of study for over 200 years. Changes in exercise intensity and duration significantly affect lactate concentration (Beneke et al., 2011). The lactate test consists of obtaining a measure of lactate concentration from a blood sample taken by finger or earlobe prick and placed in a lactate analyzer. The normal blood lactate concentrations considered since the second half of the 20th century were 0.8 to 2mM/l, while inside the cell it can vary from 1 to 1.8 mM/l. Lactate was considered an anaerobic metabolic waste, a paradigm that changed in the first half of the 21st century and is responsible for cellular acidosis. Lactate is a metabolic intermediate that is constantly produced and removed, and its concentration depends on the ratio of the rate of production to the rate of removal, which has been considered as the lactate turnover. It is a precursor of glucose. Lactate is a gluconeogenic substrate, which involves the production of glucose from non-glycosylated molecules, and when formed it alkalinizes the acid-base state (Fernandez et al., 2019).

With training, improvements in sporting performance are sought through different stimuli (the load), the evaluation of the different quantified loads serves to manage the planning in an optimal way the intensity levels. The intensity of training is the most important variable in the prescription of resistance work in which determines the specificity of the stimulus, which must be assessed and distributed over time in a specific way for each athlete (Perez et al., 2019). The manipulation of intensity, its duration and frequency, aims to maximize performance and minimize injuries. In cycling endurance is the main capacity for performance improvement, and predicting the transition of aerobic - anaerobic zones is necessary to be able to determine the different areas of training intensities. To predict training zones the lactate threshold

measurement is one of the main methods, and on the other hand with power meters the concept of functional threshold (FTP) is more widely used to determine training zones (Ferney & Leguizamo, 2020). The work planned for the improvement of aerobic and anaerobic areas have objectives, depending on the seasonal phase, of functional improvements that contribute to the improvement of sports performance such as increased capacity to store glycogen at the muscle level, increased muscle capillarization, conversion of fast to intermediate fibers, delaying the onset of lactate. Currently, the advance in technology applied to sports training allows us to access portable hardware with information such as geo position (GPS) and power meters that facilitate access to information from the training session, which the assessment is permanent and in real time, allowing a quantification of the planning and a physiological profile of the athlete, and a work according to the training zones.

Methods

This study consists of performing an incremental progressive load test on 10 amateur volunteer cyclists on an intelligent roller to which each cyclist's bicycle is adapted. The variables are recorded every 4 minutes in steps of 30 W of power, and the % of SmO2 and lactate concentration (mMol/l) are recorded.

Sample

For the present study, the sample as a subset of individuals of the population to be studied was considered. The sample of this study is non-probabilistic according to selection criteria that considered suitable to include for the study those subjects who comply with being trained cyclists, with the practice of cycling for at least 2 years of consecutive training. The cyclists in the sample represent the Elite category within the framework of the classification given by the International Cycling Union (UCI) in terms of being older than 23 years and in activity. The participation of the sample subjects was voluntary, as long as they complied with the established requirements and signed the consent regarding the handling of biological samples.

The N of the initial sample is made of 10 subjects. In the sanitary world frame affected by the Coronavirus, it was requested to lower the n of the sample having been modified to N 6. The 6 subjects of the sample are male, with an average age of 28 ± 5, an average body weight of 66 ± 6 kg, and an average height of 1.70 ± 0.04m.

There is no specific indication to the subjects of the sample regarding the type of intake to be performed prior to the test. Each subject makes the usual intakes to their individual routines. The information of their intakes was collected up to 2 hours before the test in order to have one more input at the time of the conclusions, and it consisted of simple carbohydrates and proteins.

Measuring instruments and techniques

A Tac Flux 2 model smart roller capable of measuring power in watts (w) is used. A portable Humon Hex, near-infrared spectroscopy (NIRS), with two light sources in the window and three photodetectors to measure the intensity of the light that propagates through the skin, is placed on each cyclist's right leg at the level of the external vastus. Via Bluetooth it communicates with a smartphone through the Moxzones app, which displays the % of SmO2 and colored training zones in real time through the data field downloaded to a Garmin device. Training zones are determined by color, green (steady state): when oxygen supply and consumption in the muscle are balanced, the athlete is training at a sustainable pace; orange

(approaching limit): when the muscle begins to consume more oxygen than it is being supplied, the athlete is approaching his body's limit; red (limit): when the muscle is consuming significantly more oxygen than is being supplied, the athlete is training at an unsustainable pace; blue (recovery): when the oxygen supply is greater than the consumption in muscle, meaning the athlete's muscles are recovering. Lactate measurement is done through blood samples placed in BM-Lactate reagents at Roche Laboratory's and analyzed with Accutrend Plus, which measures lactate concentration (mMol/l).

A comparative cut-off test was used, and SPSS 1.5 software was used in the statistical analysis. To establish the relationship between SmO2 and lactate concentration, Pearson's linear correlation coefficient was used. The power of lactate threshold and oxygenation threshold was calculated by a double linear regression method. The lactate threshold power was determined for each n of the sample evaluated for the value of 4mMol/l.

Procedure

Prior to the test, each cyclist receives written information about the procedures and aims of the research, together with a declaration of consent in accordance with the principles established in the Declaration of Helsinki, which each cyclist signs autonomously. For this study, an incremental progressive load test with an adapted protocol (Padillla et al. 1991) was performed on volunteer cyclists, who had at least 2 years of consecutive training. Each cyclist using their own bicycle that is adapted to the smart roller. A portable muscular near-infrared spectroscopy (NIRS), the Humon Hex device, is placed on each cyclist's right leg at the level of the vastus externus, and the % of SmO2 is continuously recorded. The device is attached to a strap around the thigh with a Velcro fastener (see Figure 1 and 2), and the muscle oxygen level detectors are attached to the skin. A capillary blood sample is taken by digital puncture and placed on a test strip. The lactate concentration (mMol/l) is measured during the last minute of each 30W step every 4 minutes. The steps are performed until exhaustion, which is indicated by each cyclist when they cannot continue pedaling.

Figure 1. Humon Hex device location

Results

SmO2 and Lactate Trend

The results are presented of the trend behavior of the % of SmO2 and lactate concentration recorded in the power increments carried out on the 6 subjects, represented in a scatter diagram in which it can be seen that as the intensity increases, the availability of muscular oxygen decreases; the muscle desaturates manifesting a decrease in the % of SmO2 (see Figure 2), while the increasing exercise intensity blood lactate increases (see Figure 3). As the intensity (W) of exercise increases, the availability of muscle oxygen needed for oxidative metabolic reactions decreases, oxygen is responsible for oxidizing the available muscle glucose and thus supplying energy to support the demands of exercise. With increasing intensity, the muscles cannot meet the demand for oxygen, so the catabolism of glucose produces lactate and increases its concentration as a product of the lactic anaerobic metabolic pathway for energy.

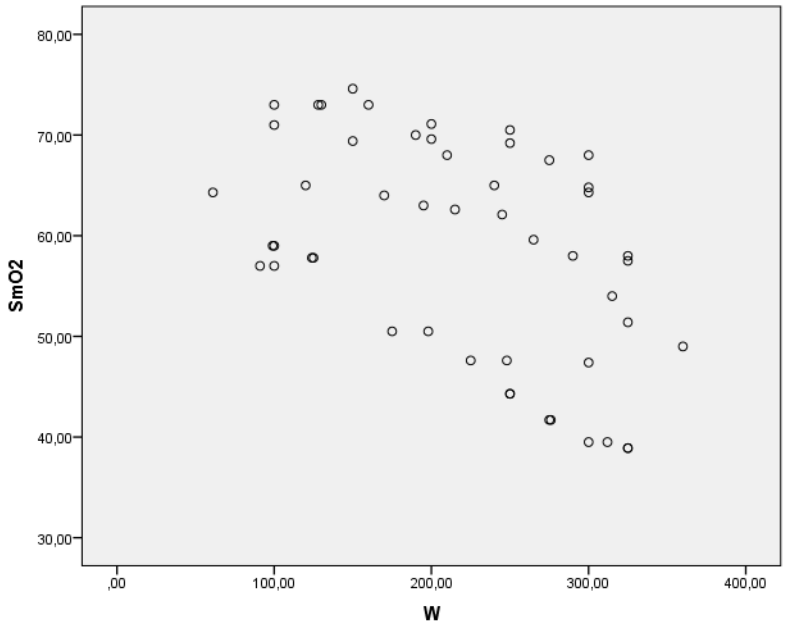

Figure 2. SmO2 and Power Scatter Plot

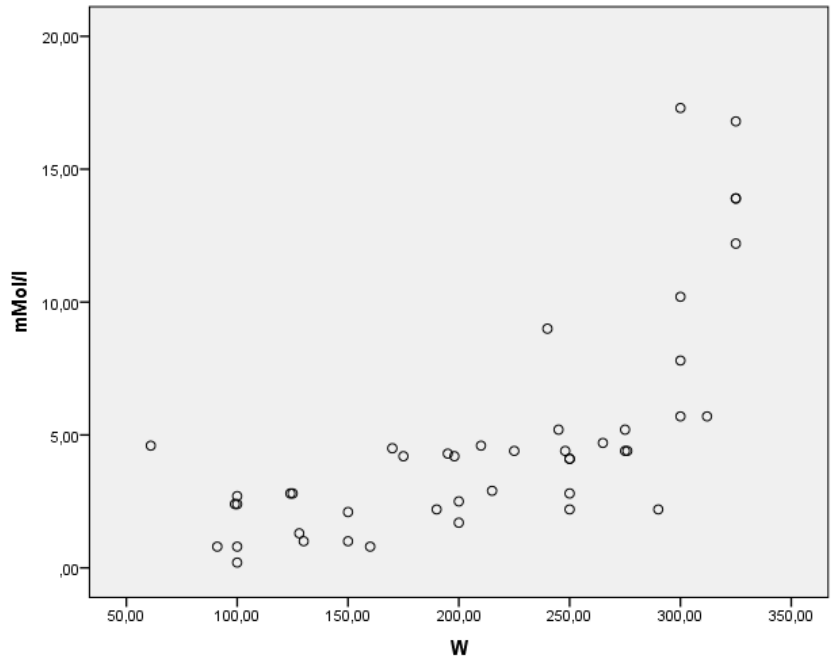

Figure 3. Scatter plot of lactate concentration and power.

Initial averages

At the beginning of the test, prior to the progressive increases in load, the SmO2 and lactate concentration of the subjects were recorded. The average results obtained were 64.3 % ± 9.7 % of SmO2 (see table 1) and lactate concentration of 0.86 ± 0.72 mMol/lt (see table 2).

Table 1
Average % of SmO2 at the beginning of the test

SmO2 resting Mean	N	Standard deviation
64	**6**	**5,3**

Table 2
Average lactate concentration at the beginning of the test.

Lactate Mean	N	Standard deviation
1,6	**6**	**1,7**

Correlation analysis

Pearson's correlation was calculated for each of the subjects in the sample and the average was - 0.87± 2.7 (see Table 3). From the Pearson's correlation analysis it is obtained as a result that the lactate concentration and SmO2 have a negative relationship, a contradictory correlation between them given that while the value of SmO2 decreases, the value of lactate concentration increases. This negative correlation expresses an inverse behavior between both variables, which means that the availability of muscular oxygen as the intensity increases, it decreases, and the lactate concentration shows the opposite behavior as the power increases, its concentration increases.

Table 3
Pearson's mean correlation between lactate concentration and % of SmO2.

SmO2 Mean	N	Standard deviation
-0,8	**6**	**0,1**

Power Lactate and SmO2 Thresholds

For each subject the % SmO2 corresponding to the Lactate Threshold power is determined. The average matched lactate threshold (4 mMoles/lt) was 62 % ± 8.14 % of SmO2 (see Table 4). As for the % of SmO2 data obtained from the NIRS device, the Humon Hex software algorithms, estimated the lactate threshold at an average time difference of 87± 27.5" at an average power of 13± 18.5 W.

Table 4
Average % of SmO2 of lactate threshold.

SmO2 Mean	N	Standard deviation
62	**6**	**8,1**

Discussion

SmO2 and lactate behavior

It is found that before starting the test there is lactate concentration in each subject between 0.8 to 2mM/l in the blood, normal concentrations as indicated in studies (Brooks, 2020) agreeing that lactate production occurs at rest, as well as upon exposure to exercise. Banishing the idea that lactate production occurred in anaerobic conditions at the cellular level. The lactate formed even in resting conditions is removed by cardiac and skeletal muscles, but when production exceeds the rate of removal by intense exercise, lactate accumulates and increases its concentration.

As in other studies (Farzam, Starkweather, et al., 2018), with the demand for greater power the oxygen available in the muscle is less, the % of SmO2 decreases and increases in recovery. The progressive loads and the effort of the subjects influence both lactate concentration and % of SmO2, the intensity of exercise influences the ability to produce energy presenting measurable changes at the physiological level; lactate values increase while SmO2 values decrease. Being glycolysis (San-Millán et al., 2020) one of the main energy pathways due to its high rates of ATP generation in anaerobic conditions that satisfies the energy needs, and the release of hydrogen ions begins to overcome its oxidation in the respiratory chain.

Both techniques used are indirect measures of oxidative metabolism, the NIRS device for measuring the % of SmO2 is a technique that ensures accurate quantification of oxygenation changes within the muscle representing the kinetics between supply and demand of oxygen (O2); and blood lactate concentration is sensitive to changes in intensity and duration of the exercise. The measurement of SmO2 behavior is in real time and is recorded while performing the exercise, obtaining blood lactate is invasive and at a certain time when the exercise is paused.

Lactate threshold and power

Blood lactate levels are used to help determine training exercise intensity according to (Fernandez et al., 2019). The lactate threshold allows the identification of training zones to plan loads for performance improvements on an individual basis, understanding that oxidative improvements in glucose are fundamental to avoid lactate increase. During intense exercise, energy is obtained through glycolysis, and the reduction of pyruvate to lactate occurs to sustain the energy demand, but if lactate is not removed, its H+ accumulate and make it impossible to continue exercising.

It is established in each subject the power (W) corresponding to the lactate threshold value of 4mMol/l, which is where the anaerobic aerobic transition occurs as stated and serves as a fundamental data to establish the training zones proposed by (Ferney &Leguizamo, 2020) and make the prescription of the intensity. It was not possible to find a power value (W) of the standard absolute threshold for all the subjects of the sample in agreement with another study (Farzam, Starkweathear, et al., 2018) where there is a difference between the powers corresponding to the 4 mMol/lt of the lactate threshold among the subjects, making it clear as proposed by (San-Millán et al., 2020) the individual metabolic characteristics depending on the amount of lactate produced at a given power. The different potencies in which subjects generate the concentration of 4mMoles corresponding to the lactate Threshold allow to identify those subjects who have better lactate elimination capacity are efficient and therefore export less lactate to the blood (Brooks, 2020).

SmO2 and power Lactate Threshold

In addition to the % of SmO2 values generated by the Humon Hex, it also shows the color graphs, and the interpretation matches according to the rhythm posited by (Farzam, Starkweather, et al., 2018) in the way the muscles are consuming oxygen as the intensity of exercise increases, it is presented orange and transforms to red; the transition from orange to red constitutes the lactate threshold estimate. In the absence of a standard absolute threshold power value (W) for all subjects in the sample, the % of SmO2 per se cannot be considered as a measure of lactate threshold power estimation as there is no % of Smo2 power value to indicate lactate threshold. But making the comparison between the lactate threshold power to each subject, and the kinetics of muscle oxygen saturation with the threshold estimation by the Humon Hex software algorithm gives an average difference of 13W ± 18.5 power and an average time difference of 87"± 27.5, being in another study (Farzam, Starkweather, et al., 2018) the average difference of 21.4W and in less than 3' the lactate measurement. Therefore,

it can be considered the result of the analysis of the Humon Hex software as a possible tool to identify training zones for being a non-invasive, reproducible technique, and with results in real time the diffusion of its use is promising in training as in competition.

Conclusions

In this study we see that the intensity zones that can be established from the determination of the lactate threshold, with the records of the % of SmO2, it is also possible to identify the training zones. When correlating a physiological parameter such as lactate concentration with the metabolic zones established from the % of SmO2 through the NIRS technique, it can be observed that in the anaerobic threshold zone there is a correlation where the % of SmO2 decreases due to the O2 demands of the muscles, and the lactate curve that was stable between production and its removal presents a breaking point with increased production of lactate in the blood.

Limitations

As for the limitations, it is observed that SmO2 both at basal level and at the lactate threshold presents a wide dispersion of its values that limits its usefulness. Although the n of the sample is low, the hypothesis can be confirmed, and these data can be considered promising to apply the Humon Hex as an equivalent tool to the lactate test in the indirect determination of the intensity, with the advantage of being non-invasive and efficient in time and cost. As for lines of improvement of theoretical order would be good to have more research in this regard and have a greater n that gives us greater certainty of the data. As for the methodological ones, it would be good to have an impact on the similarity of the intakes prior to the test and to consider anthropometric data, mainly folds and subcutaneous fat in relation to the incidence in the use of the NIRS.

Recommendations

The Humon Hex NIRS device is a tool that, unlike the lactate test, is non-invasive and real-time data can be obtained from the muscle involved in the exercise. It can be used to prescribe training loads, the interpretation of kinetics, and the % of SmO2 changes during exercise can be a very useful reference to determine exhaustion or recovery of the cyclist. The combined use of Humon Hex with the measurement of other parameters such as heart rate, power, or speed, among others, could contribute to the control of training loads and thus understand the physiological repercussions caused by different stimuli. Using this data in the training process together with other variables would be a great advantage that would increase the possibilities of control and enrich the criteria for decision making, which is essential to achieve improvements in sports performance. As for future lines of research, to be able to investigate if the same athletes following a training plan with a view to the improvements of the aerobic capacity, exposed to the same test, it is possible to find greater manifestations of power in the lactate threshold and desaturation zone.

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MONITORING OF TRAINING AND COMPETITION LOADS IN WOMEN'S SOCCER: A CASE STUDY

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Abstract. The monitoring of loads is investigated to diagnose the recovery and optimisation of athletes. The aim was to evaluate tools for monitoring training and competition loads to know the states of field players in women's soccer. 23 participants aged 22±3 years from the 1st Catalan Regional Division (Group A) were observed during the 2018-2019 season. The five types of microcycle (ME) were chosen. Microsoft Excel software was used to record the information and determine the external and internal load, injury risk and define recovery and optimisation times and the SPSS program for statistical analysis. The results show an Average Specificity (EM) of a targeted-special character together with a lower Load Balance (LB) in the Maintenance Microcycle (MM): 0.32p; and in the Competitive Microcycle (CM) with physical-technical-tactical balance: 0.86p. Preparatory Microcycle (PM) obtained a Monotony Index (MI) of 6.54p; the Targeted Transformation Microcycle (MTD) of 8.55p and Special Transformation Microcycle (STM) of 5.89p. The highest relative fatigue percentage (%FR) was 85% for MTD and 32% for MC. The highest RPE was for MC = 8.88p; MTD = 8.04p and MTE = 7.02p. Sleep quality and stress were high in the MC and muscle damage and cumulative fatigue in the MP and MTD. Recovery is reflected in all ME after 48h in the CMJ. These calculations are accepted as effective tools to indicate the evolution of load dynamics as long as they can be contextualised.

Keywords: load monitoring, structured training, complexity science, women's soccer.

MONITORIZACIÓN DE LAS CARGAS DE ENTRENAMIENTO Y COMPETICIÓN EN EL FÚTBOL FEMENINO: CASO PRÁCTICO

Resumen. La monitorización de las cargas es investigada para diagnosticar la recuperación y optimización de los deportistas. El objetivo del estudio es evaluar herramientas de monitorización de las cargas de entrenamiento y competición para conocer los estados de las jugadoras de campo en el fútbol femenino. 23 participantes de 22±3 años de la 1ª División Regional Catalana (Grupo A) fueron observadas durante la temporada 2018-2019. Se escogió los cinco tipos de microciclo (ME). Se utilizó el programa de Microsoft Excel para registrar la información y determinar la carga externa e interna, riesgo de lesión y definir los tiempos de recuperación y optimización y el programa SPSS para el análisis estadístico. Los resultados muestran una Especificidad Media (EM) de carácter dirigido-especial junto a un Load Balance (LB) más bajo en el Microciclo de Mantenimiento (MM): 0,32p; y en el Microciclo Competitivo (MC) con equilibrio físico-técnico-táctico: 0,86p. Microciclo Preparatorio (MP) obtuvo un Índice de Monotonía (IM) de 6,54p; el Microciclo de Transformación Dirigido (MTD) de 8,55p y Microciclo de Transformación Especial (MTE) de 5,89p. El porcentaje de fatiga relativa (%FR) más alta fue 85% para el MTD y 32% para el MC. El RPE mayor fue para MC = 8,88p; MTD = 8,04p y MTE = 7,02p. La calidad del sueño y estrés fueron

altos en el MC y el daño muscular y fatiga acumulada en los MP y MTD. Se refleja una recuperación en todos los ME tras 48h en el CMJ. Se acepta estos cálculos como herramientas eficaces para indicar la evolución de las dinámicas de la carga siempre y cuando puedan ser contextualizados.

Palabras clave: monitorización de la carga, entrenamiento estructurado, ciencias de la complejidad, fútbol femenino

MONITORING OF TRAINING AND COMPETITION LOADS IN WOMEN'S SOCCER: A CASE STUDY

Abstract. The monitoring of loads is investigated to diagnose the recovery and optimisation of athletes. The aim was to evaluate tools for monitoring training and competition loads to know the states of field players in women's soccer. 23 participants aged 22±3 years from the 1st Catalan Regional Division (Group A) were observed during the 2018-2019 season. The five types of microcycle (ME) were chosen. Microsoft Excel software was used to record the information and determine the external and internal load, injury risk and define recovery and optimisation times and the SPSS program for statistical analysis. The results show an Average Specificity (EM) of a targeted-special character together with a lower Load Balance (LB) in the Maintenance Microcycle (MM): 0.32p; and in the Competitive Microcycle (CM) with physical-technical-tactical balance: 0.86p. Preparatory Microcycle (PM) obtained a Monotony Index (MI) of 6.54p; the Targeted Transformation Microcycle (MTD) of 8.55p and Special Transformation Microcycle (STM) of 5.89p. The highest relative fatigue percentage (%FR) was 85% for MTD and 32% for MC. The highest RPE was for MC = 8.88p; MTD = 8.04p and MTE = 7.02p. Sleep quality and stress were high in the MC and muscle damage and cumulative fatigue in the MP and MTD. Recovery is reflected in all ME after 48h in the CMJ. These calculations are accepted as effective tools to indicate the evolution of load dynamics as long as they can be contextualised.

Keywords: load monitoring, structured training, complexity science, women's soccer.

Introduction

The planning of any sport discipline has been and is the transcendental focus for coaches and any sport professional. It always seeks to optimize the level of athletes without the presence of possible injuries that interrupt this evolution.

In the case of team sports and, in essence, those that interact in a shared space (DIEC), traditional planning has been designed, long in time, which opened a wide range of issues as its organization and distribution in time distanced considerably from the requirements of much tighter schedules with weekly repeated competitions (Martín et al., 2013; Seirul-lo, 2000, 2002, 2017; Roca, 2008). These schedules based on mechanistic and behaviorist theories prioritized reversible and repeated linear relationships applicable to all athletes, where quantity was the base of the pyramid to subsequently adjust to quality (Seirul-lo, 2017); in this way, the competition was the focus of attention and the athlete took second place.

New planning proposals emerged over the years based on Cartesian views of sciences such as biology and human sciences along with other sciences derived from mathematics, physics, and chemistry as would be the case of the Theory of Dynamic Systems, Systems Theory, Complex Thinking, or Deep Ecology (Arjol, 2012, cited by Martin, 2019; Seirul-lo, 2017). The sample of this is the Structured Training used in this study by Professor Seirul-lo, which exemplified these theories towards DIECs where the "whole" is more than the sum of the parts (stated by the German philosopher Christian von Eherengields) as their inter- and intra-system relationships, must be taken into account (Torrents, 2005).

The monitoring of training loads aims to control these non-linear relationships, coming from chaos theory, in order to classify team members according to their states, reducing the probability of injury, and increasing the time of participation in competition resulting in greater episodes of supercompensation (Impellizzeri et al., 2019, cited by Suarez et al., 2020; Gonzalez, 2020; Gabbett, 2016).

Both injury risk and supercompensation are defined in the Theory of Dynamic Systems as negative or positive feedbacks, respectively. The former refers to the persistence of conditioning factors that prevent change and, conversely, the latter refers to the system adjusting to changes in internal and external conditioning factors (Torrents, 2005). Its measurement is described by Siff and Verchoshansky (2000), cited by Torrents (2005), as the search for sporting excellence as the availability of players is proportional to the success of the team (Suarez et al., 2020). These same authors state a ratio of two injuries per player during the season in professional teams, which can expect a total of 50 injuries in that competitive period. Therefore, proper management of training loads will result in the persistence of players in competition in a balanced way (Gabbett, 2016).

Traditionally it has been interpreted high loads with increased risk of injury, but Gabbett (2016) describes the 'Paradox of injury prevention in training' where those athletes accustomed to training with high doses in loads have less risk of stopping their activity by the appearance of these injuries and vice versa. This is not due, according to their statements, by training per se but by an inadequate program characterized by excessive and rapid changes, and this is reinforced by more recent studies such as that of Suarez et al. The importance of monitoring and control of training and match loads will be convenient to avoid the presence of negative feedbacks and ensure optimization processes. Gabbett (2016) justifies its use up to twice a day and for periods of weeks and months.

To identify these feedback loops, we allude to the measurement of internal load, physiological and psychological organism response, and external load, parameters designed by coaches and physical trainers (González, 2020) under the Preferential Simulation Situations (SSP), that is, tasks created under the theoretical bases of the TSD and similarity to the internal logic of the sport itself, in this case women's soccer, (Camenforte et al., 2021; Pons et al., 2020; Seirul-lo, 2017) as tools for monitoring loads.

Thus, the aim of the study is to evaluate tools for monitoring training and competition loads in order to know the condition of field players in women's soccer.

Method

Participants

The study group was the first women's team of a regional club composed of 23 players, four of whom were eliminated from the study because they were injured throughout the competition. The inclusion criteria consisted of being part of the team from the start date of the preseason and not having suffered a previous injury that caused the loss of soccer practice for more than 4 weeks (Fuller et al., 2006, cited by Suarez et al., 2020). Those players who had an absence equal to or greater than that period were discarded from the study.

The average age was 22±3 years (17-30 years). The league in which the matches were played belonged to the 1st Catalan Regional Division (Group A) during the 2018-2019 season. It is characterized as a heterogeneous team as there are players who come from the 2nd National Women's Division with participation in training sessions of the first teams of the Iberdrola League, First Spanish National Women's League, and others who are starting their soccer careers. This team was characterized as a team with

predominance in the technical-tactical structures and, on the contrary, a deficiency in the conditional. The competition and, therefore, the teams that make it up were analyzed and classified in the opposite way to our team: dominance of the conditional before the other structures.

Study design

A descriptive and cross-sectional design and study of the planning of the 2018-2019 season of the women's first team of a Catalan regional club was carried out. The training and competition loads of the 41 existing microcycles with 33 matches played (29 official and 4 friendly) were recorded. Both training sessions and matches were played on artificial turf.

Procedure

The difficulty of the matches was classified by numbering from 1 to 10 in order to frame the type of microcycle with its corresponding characteristics, according to the week in which they were played.

Each week consisted of three training days (Tuesday, Thursday, and Friday) plus a match at the weekend (mainly on Sunday). The spatial layout of the training sessions varied depending on the day as they had to share the sports facilities with other teams. The sessions corresponding to Tuesday half of the 11-a-side soccer field was used, Thursday was carried out in the 7-a-side soccer field, and on Friday the first half of the training was in 4-a-side soccer, and later in the 11-a-side soccer half. All the sessions were started at 21:00 until 22:30, duration of 1 h 30 min of which the first 30' were not available because they were used by other teams.

For the training load analysis, five different type microcycles were chosen (preparatory = MP, targeted transformation = MTD, special transformation = MTE, competitive = MC, and maintenance = MM) and randomized in time throughout the entire 2018-2019 season, in order to illustrate the morphological and contextual varieties of each moment.

The MP located in the first week of the three that correspond to the preseason, intended to follow the proposed indications in which the Concentrated Volume of Specific Load prevails the first days while the Technical-Tactical Volume and Intensity are increasing, reaching their highest levels on Friday (Solé, 2006; Arjol, 2012; Seirul-lo, 2017; Roca, 2008). The preseason gathered three microcycles with friendly competitions. The coaching staff proposed strategies to condition themselves to the needs of a correct dynamic of loads so the training time amounted to 2 h.

The MTD is located in the last week of the post season, where there was a loss of fitness (Bompa, 2003), but at the same time new content was introduced for the following season.

The rest of the microcycles were distributed during the competitive period. In the case of the MTE, week 9, it was focused on a high volume to seek optimization in the next two weeks because the matches were played with the top rivals. This type of microcycle is not frequent in this competitive phase, but it was used as a strategy to counteract the high intensity that was given since the beginning of the preseason. The MM and MC located in the second round, No. 23 and No. 28 respectively. The MC was considered the most important match of the whole season because it depended, to a large extent, the goal of promotion.

As for the subjective internal load, the Wellness Test was used, considered one of the most important monitoring tools by "The UEFA Elite Club Injury Study" as it is

considered a reliable, economical, and easy to apply method (McCall et al., 2016; Heidari et al., 2019; and Saw et al., 2015; Barça Innovation Hub Team, 2019), where the quality of sleep, muscle pain, fatigue, and stress are scored from 1 (minimum) to 7 (maximum). All players at breakfast sent a message via mobile device to the technical staff indicating their status in each of the defined parameters. The RPE test was recorded at the end of the sessions with individual annotation.

Statistical analysis

The Microsoft Excel program was used to analyze the data by means of various formulas. The total estimated and performed volume (in minutes), character of the proposed and perceived effort (RPE or CR10 adapted from Foster & Lehmann, 1998; where 0 is recovery and 10 is maximum effort), and total intensity according to the level of specificity that each task entailed were recorded. Specificity levels were scored as follows: general = 0.5-0.65; directed = 0.66-0.75; special = 0.76-0.85; competitive = 0.86-0.99, and divided = 1.

The calculation of the workload measured in Solé Load Units (2002) and Average Specificity (AS) was carried out based on the total sum of the Specificity Index of each task divided by the number of tasks performed in that session. As a result, other indirect parameters were estimated to give conjecture to what was established in accordance with reality: Monotony Index (MI), Load balance (LB), and Relative fatigue measured in percentage (%RF).

MI (equation 1) is an indicator of the daily variability of training that is closely related to the onset and appearance of symptoms of overtraining (Foster, & Lehmann, 1998).

$$\text{Monotony Index (MI)} = \frac{\text{Average weekly load}}{\text{Standard deviation}} \qquad \text{(Eq. 1)}$$

Secondly, the LB of the ME, the result of the division between external load (mean of the total volume of the ME by the mean of the CR10) and internal load (mean of the total volume of the ME by the mean of the level of specificity of the ME), identifies the predominance of the type of stress that the microcycle generates on the players (physical or technical-tactical stress). On the other hand, the %RF indirectly tested the level of fatigue of the players during the designed microcycle. It was determined following equation 2.

$$\text{RF (\%)} = \frac{\text{Weekly load x Monotony index}}{\text{Maximum load of the season}} \text{ x } 100 \qquad \text{(Eq. 2)}$$

The execution of the countermovement jump (CMJ) was also performed before and after the session (30' after finishing), and after 48 h in order to observe the recovery capacity of the athlete for being a predictor at a neuromuscular level (Jiménez et al., 2018 & De Hoyo et al., 2016). The MyJump2® APP was used as a monitoring method. The total mean (sum of the parts and standard deviation) was calculated for the subjective internal load.

With this data, we sought to identify the correlation between the theoretical and the experienced in order to execute the relevant modifications that would guide the established objective. It should be clarified that the results section will only show the data record after the conclusion of the training sessions.

The effect of the different work methods was studied by analysis of variance (ANOVA) followed by separation of measures using the Turkey method when necessary. Previously, it was checked that the hypotheses of normality and homoscedasticity of the

data were fulfilled. This analysis was carried out using SPSS 6.0 (SPSS, Inc., Chicago, USA).

Results

The data analysis did not identify (Figure 1) an increase in AS per training day in relation to intensity. The level of specificity was similar during the week with the exception of the match day, Sundays, with the maximum demands. A tendency towards the prevalence of targeted and special tasks was detected, as no significant differences were found.

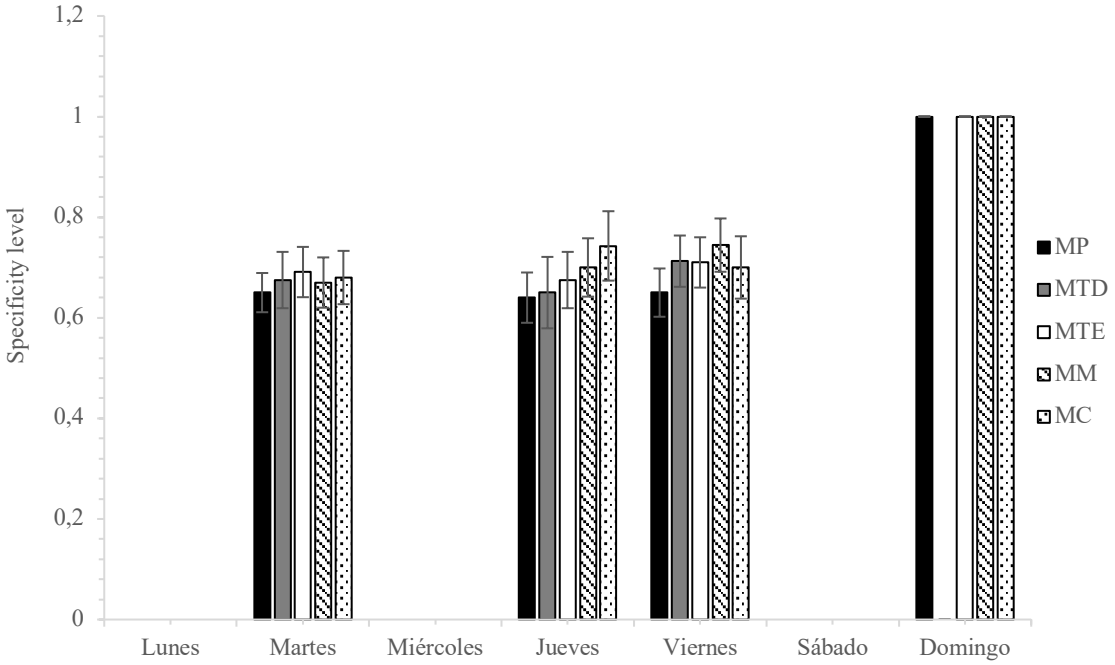

Figure 1. Mean Specificity (mean ± SEM) per day and microcycle.

Note: Average Specificity (AS), Preparatory Microcycle 1(MP), Directed Transformation Microcycle (MTD), Special Transformation Microcycle (MTE), Maintenance Microcycle (MM), and Competition Microcycle (MC).

The MI identified (Figure 2) a clear tendency to reduce the risk of overtraining symptoms appearing during the competition period and in the most relevant microcycles, as was the case of the MC. On the contrary, at the end of the post-season, this index was exponentially increased; a fact that happened in the MTD.

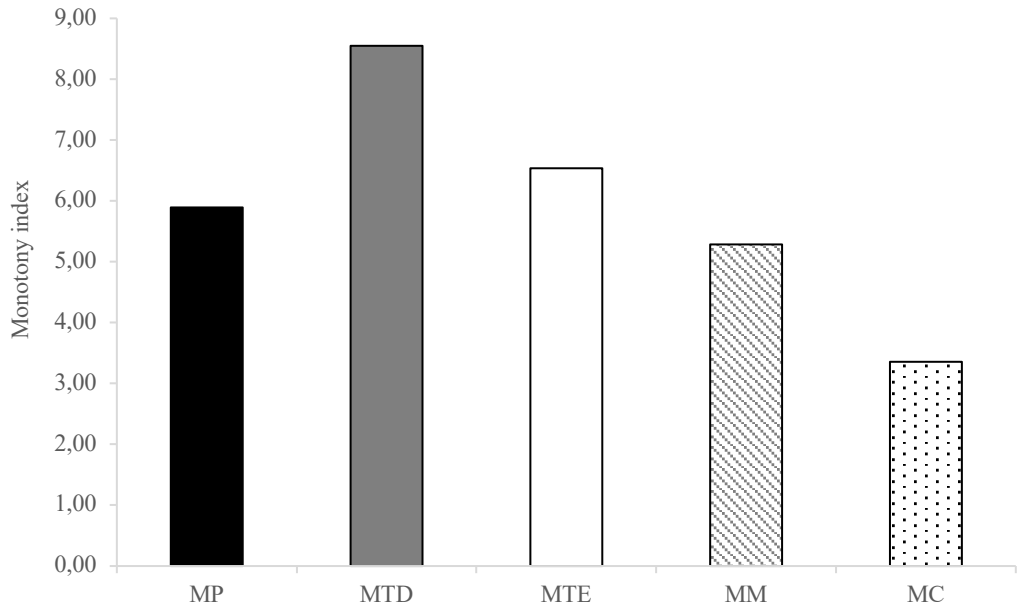

Figure 2. Monotony Index (MI) of each microcycle.

Note: MP = Preparatory Microcycle; MTD = Directed Transformation Microcycle; MTE = Special Transformation Microcycle; MM = Maintenance Microcycle; MC = Competition Microcycle.

The LB (Figure 3) presented the type of stress that the designed and executed tasks caused on the players, where all the microcycles were around the balance between physical and technical-tactical stress but with a greater inclination towards the physical component, especially in the MM with a score of 0.32 and, on the contrary, the MC with a more balanced scale towards these two types of elements.

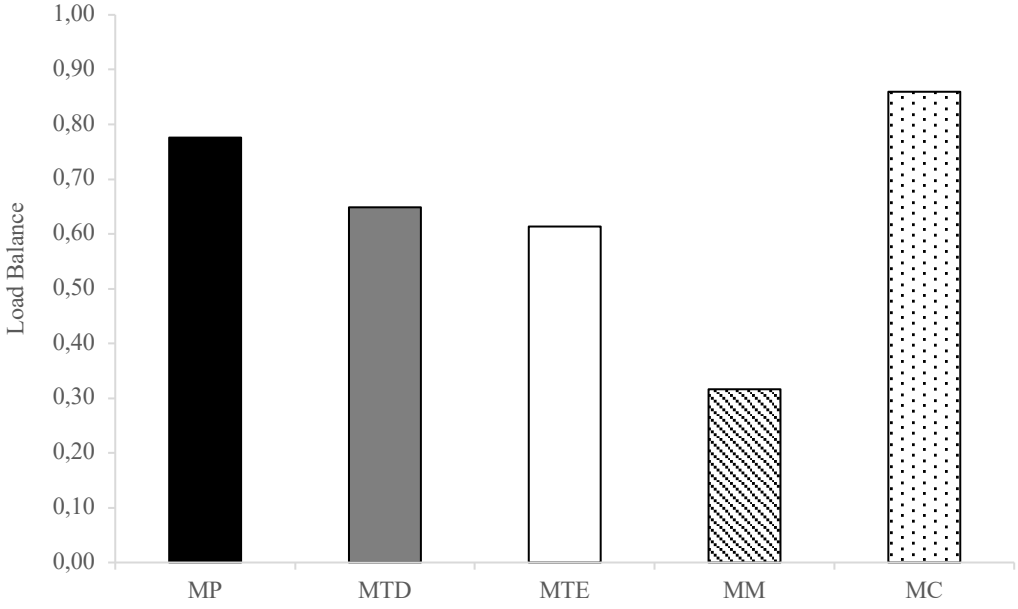

Figure 3. Weekly Load Balance (LB) in each microcycle.

Note: MP = Preparatory Microcycle; MTD = Directed Transformation Microcycle; MTE = Special Transformation Microcycle; MM = Maintenance Microcycle; MC = Competition Microcycle.

The %RF (Figure 4) marked the probability of fatigue of the players before the designed microcycle showing a clear propensity to decrease before the weeks located in the season and more demanding, facilitating a predisposition on behalf of the players. As an example is the MC of 32% score. The MTD acquires a higher percentage, 85%, because it is located in the last week of the post season in which a playful-competitive component of high specificity with transfer to the next season was acquired.

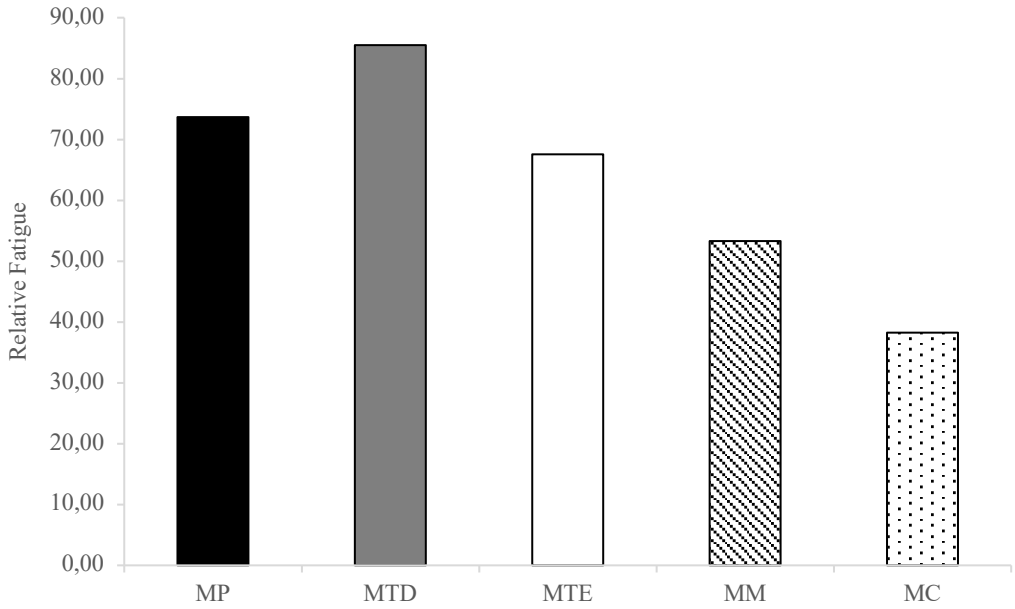

Figure 4. Percentage of relative fatigue (%RF) of each microcycle.

Note: PM = Preparatory Microcycle; MTD = Directed Transformation Microcycle; MTE = Special Transformation Microcycle; MM = Maintenance Microcycle; MC = Competition Microcycle.

The results found by means of the CMJ jump test (table 1) indicated changes in the performance of the players. In addition, no recovery is seen after 48 h in all microcycles.

Table 1

Mean and Standard Error of the mean (SEM) of the countermovement jump (CMJ) in centimeters of each selected microcycle before and after, and after 48 h of the training session and match.

	CMJ (cm)				
	MP	MTD	MTE	MM	MC
Before	20,67 (±0.46) $^{b\ A}$	24,48 (±0.57) $^{b\ B}$	24,66 (±0.56) $^{b\ B}$	25,63 (±0.61) $^{b\ B}$	25,98 (±0.56) $^{b\ B}$
After 30'	18,56 (±0.46) $^{to\ A}$	19,65 (±0.57) $^{to\ A}$	22,98 (±0.56) $^{to\ B}$	23,08 (±0.61) $^{to\ B}$	23,35 (±0.56) $^{to\ B}$
After 48 h	18,39 (±0.46) $^{to\ A}$	18,86 (±0.57) $^{to\ A}$	22,02 (±0.56) $^{to\ B}$	22,19 (±0.61) $^{to\ B}$	22,81 (±0.56) $^{to\ B}$

Note: PM = Preparatory Microcycle; MTD = Directed Transformation Microcycle; MTE = Special Transformation Microcycle; MM = Maintenance Microcycle; MC = Competition Microcycle.
^{z} different lowercase letters indicate significant differences (P<0.05) according to Tukey's test by columns; different uppercase letters indicate significant differences (P<0.05) according to Tukey's test by rows.

In the subjective internal load of the players (table 2), two microcycles stand out above the others that are the MTD, CR10 of 8.04 points, for its spatial location previously mentioned carrying the accumulated fatigue of the whole season, and MC for being the most relevant of the whole competitive period, 8.88 points on the Borg scale.

Table 2

Mean and Standard Error of the Mean (SEM) of the internal load of the players in the Wellness Test (1-7p) and in the Borg Effort Perception Test (CR10; 0-10p).

	Wellness Test				**RPE or CR10**
	Sleep quality	Perceived muscle damage	Fatigue level	Amount of stress	
MP	1,03 (±0,02) ^{a}	6,01 (±0,07) ^{c}	5,88 (±0,07) ^{d}	2,16 (±0,08) ^{a}	6,69 (±0,18) ^{a}
MTD	3,04 (±0,07) ^{c}	6,86 (±0,03) ^{d}	6,15 (±0,06) ^{d}	5,24 (±0,09) ^{c}	8,04 (±0,14) ^{b}
MTE	2,54 (±0,06) ^{b}	5,87 (±0,07) ^{c}	2,89 (±0,09) ^{a}	3,45 (±0,1) ^{b}	7,02 (±0,13) ^{a}
MM	2,68 (±0,06) ^{b}	4,39 (±0,09) ^{b}	5,47 (±0,09) ^{c}	3,15(±0,08) ^{b}	6,94 (±0,11) ^{a}
MC	6,78 (±0,03) ^{d}	4,46 (±0,1) ^{a}	3,85 (±0,1) ^{b}	6,94 (±0,02) ^{d}	8,88 (±0,07) ^{c}

Note: MP = Preparatory Microcycle; MTD = Directed Transformation Microcycle; MTE = Special Transformation Microcycle; MM = Maintenance Microcycle; MC = Competition Microcycle.
^{z} different lowercase letters indicate significant differences (P<0.05) according to Tukey's test by columns.

Discussion

The aim of this study was to evaluate tools for monitoring training and competition loads in order to know the condition of field players in women's soccer.

The tests exposed for both external load (MI, AS, %RF), internal load (CMJ, Wellness Test, CR10), and their relationship (LB) have been selected for their capacity for adaptability and continuous modification to the ME because as indicated by Seirul-lo (2000, 2002, 2017) should not be periodized more than three microcycles followed by the large number of factors involved during the process, and this is reinforced by other authors such as Arjol (2012), which are based on the theories of the sciences of complexity. However, there are other types of tests and technologies that detail more precisely the demands of the players as would be the GPS that are so fashionable nowadays (Martín, 2019).

The results of the research indicate an AS with predominance in the tasks of spatial-directed character as no significant differences were found ($P>0.05$), so that the most dominant element after analyzing the competition is the conditional by all teams, where the repeated sprints and sprinting bouts have a great participation. Studies such as those of Datson et al. (2017), Castellano et al. (2011), and Gabbett et al. (2008), thus reinforce them. In addition, Haro & Cerón (2019) mentioning different authors and their studies on women's soccer enhance the importance of promoting this ability and, specifically, strength and speed, both argued also in men's soccer. Alcazar (2021) proposes training through complex training as an alternative to promote neuromuscular optimization by the post-activation potentiation effect and so is argued by other scientists in their research (Ebben, 1998; Carter & Greenwood, 2014; Freitas et al., 2017). The increase of this type of neuromuscular work in soccer that has been occurring in recent years exalts the importance of a good control of the training loads elaborated because its deficit is accompanied by a rise in the rate of injury risk (Nassis et al., 2019). Gabbett et al. (2008), propose, in turn, reduced games as effective methods of performance optimization, and this is supported by other more recent works such as Fradua et al. (2013), and Márquez & Suárez (2014). The calculation of the indexes exposed in the various figures will be a continuous and moving alternative to reduce this risk of injury (Clemente et al., 2021), and so it is reflected in the LB where conditional stress tends to predominate agreeing with the above; so the intentions in the periodization of training by the technical staff resemble reality.

In the research by Márquez & Suárez (2014), they analyze a semi-professional player who competes in the Spanish Second National League under the Sevilla FC SAD using a GPS device. Both the characteristics of the player and the training and matches are similar to the observational team (18 years old, 3 sessions/week plus match). They state an increase in intensity at the end of the week caused by intensive tasks with a high number of sprints but dissipating from the demands of the match. Furthermore, they state that the external load on Friday does manifest stimuli close to those of competition. This correlates with the description of the type of task to be developed by the EE (Seirul-lo, 2017; Camenforte et al., 2021). In our case, this rise is not appreciated, a fact that makes them dissipate even more of the demands of the match and, therefore, a correct dynamic of training loads according to the specificity of the tasks has not been managed.

The MP gave similar results to the other microcycles as the total training volume was 2 h, and the effective time was quite close to this amount. This was used as a tool to try to get the responses of the adaptive process characteristic of the preseason since it was formed by a block of three weeks with important competitions. This fact correlates with the arguments of Calleja et al. (2020), on the increase of important competitions in the pre-season periods that are tighter and with a "need to win" character as they enhance. Following their expositions when citing Folgado et al. (2014) and Rabelo et al. (2016), they claim that competing with high level teams makes the demands of time-movement also be raised causing a pressure to players and technical staff to accelerate the

conditioning processes by skipping steps and increasing the atypical training loads in this period. Consequently, to such factors, there will be an accentuation on the injury rate as observed in MI, where a prolongation and abrupt change of intense loads can lead to symptoms of overtraining (Foster & Lehmann, 1998; Gabbett, 2016). However, high and constant loads at the beginning of the new season will be necessary to create the relevant adaptations and set the basis for the course of the season (Arjol, 2012), so that the technical staff must be very aware of these oscillations (feedback loops that, according to the theoretical bases of the sciences of complexity, will be in a continuous process of exchange network between the system and the environment, Torrents, 2005).

As the ME acquired a more competitive nature with tasks of a high level of specificity, the MI decreased avoiding such risks as the work times: rest times were favorable to the latter (Seirul-lo, 2017). These rests were almost null in the MTD as it was located in the last week of the post season manifesting a playful-competitive nature with focus on the following season knowing that the holiday period was starting and so it is demonstrated in the %RF in which there is a higher score in said ME. However, during the competitive period, this percentage was decreasing, reaching its lowest value in the MC because the objective was the optimization of the players before the most demanding matches and, therefore, the adjuvant tasks, recovery methods, rest times, etc., were the scenarios that allowed to achieve these results (Seirul-lo, 2017).

Following the %RF exposures, the players showed an RPE in the MTD of 8.04p due to the accumulated load both in that ME and the whole competition season. The MC had an average of 8.88p being the highest figure extracted due to the external factors that characterized it. The MP obtained the lowest rating as the load imposed should be the basis for the oscillations of the load dynamics of the competitive phase (Seirul-lo, 2000, 2002, 2017). As a consequence of the increase of volume in relation to intensity, the MTE reached an average of 7.02p. Thanks to the contributions of Foster & Lehmann (1998), this data can be linked to the heart rate of the athletes and this is corroborated by studies such as that of Halson, (2014) and a large number of professionals from different sports disciplines.

It is worth noting the arguments of Ponce et al. (2021), which in their test denoted how depending on the design and orientation of the tasks, these could cause more fatigue and mental load on the players. In addition, the motivation factor also played an important role. In both cases, a modification in the RPE was detected, and this is supported by other studies cited by them. Camenforte et al. (2021) present a glossary in which they interrelate the SSP together with the level of specificity and the internal logic of soccer as tools for their evaluation, influencing the theoretical parameters on which this study and Structured Training are based.

Technicians at Liverpool John Moores University (Thorpe et al., 2015, 2016 and 2017; Barça Innovation Hub Team, 2019) have observed that Wellness Test results are more sensitive to fluctuations in daily training loads compared to other more objective tools such as those with submaximal heart rate detection, recovery, and variability, and that perceived fatigue is closely linked to total distance run at high intensity. The quality of sleep and the amount of stress are higher in the MTD and MC, the former because of their location and accumulation of fatigue for the whole period, and the latter because of the environmental factors that precede it, even though there are significant differences ($P<0.05$) between them. The highest values of muscle damage and fatigue level are in the MP characterized by sessions of large volumes and located in the first ME and the MTD for what has already been expressed. Significant differences ($P<0.05$) are found in muscle damage between these two ME but not in the level of fatigue. A dissonance is manifested in the MTE because the perceived muscle damage amounts to 5.87p over 7p in

comparison to the rest of the values with a low score, and with a CR10 also high, 7.02p, which here the focus of attention should prevail and observe the weeks that precede it to reveal possible risks of injury because the MI is also high in comparison to the other ME. On the other hand, the MM has a correct dynamic.

The method used to interrelate the arguments presented so far is the LB by means of the internal and external load of the week. There is a clear trend towards physical dominance across the MEs. Malone et al. (2016) suggest in their pioneering research in reporting associations between measures of weekly training loads alongside injury risk in elite soccer that the ratio of acute chronic load should be between 1-1.25 in both the pre-season and seasonal period and so is reinforced by various Rugby league studies, 0.85-1.35, cited by these same authors. Only the MC would resemble these values, 0.86p. However, it is important to note that these are calculated using the external and internal load and not on the chronic acute, but it may be a predictor of the risk associated with a predominance downward in the results during the passage of weeks. These same authors claim a lower risk when training loads are similar or with a progressive increase compared to peak loads, and Gabbett (2016) also corroborates this. In addition, the greatest dangers are found during the preseason but that in turn will be diminished if in this period a base of intermittent aerobic capacity is favored that should be enhanced in the previous postseason or vacation time.

To conclude, Datson et al. (2017) suggest that the proportion of explosive sprinting is higher in women's soccer than in men's soccer and also that these occur between 5 m and 10 m corresponding to 76-95% respectively. In agreement with this, Alcazar (2021) suggests that the large increase in neuromuscular component tasks is not being properly monitored and therefore causing injuries. Based on studies such as De Hoyo et al. (2016) & Jimenez et al. (2018), the Bosco CMJ jump test was proposed as a marker of recovery after session and match reflecting accumulated fatigue and muscle damage. All the results after 48 h are similar to the data after the end of the training sessions and matches alluding to the biological processes of recovery although no significant differences are found ($P>0.05$). It is important to point out that comparing the different heights there is a great variability between ME and it is due to the learning and improvement of the CMJ by the players. This can be seen in the row "before" where the significant difference is classified in two distinguishing the pre-season and in-season MEs. However, according to the temporal location of the ME, both in the MTD and MTE, the values are lower due to the accumulation of fatigue as it has been exposed.

Conclusions

The present study aimed to evaluate tools for monitoring training and competition loads in order to know the condition of field players in women's soccer.

It is affirmed that this type of calculation is a good indicator of the evolution of the training load and predictor of a good or not recovery and optimization of the performance of each of the players as long as it can be contextualized by other variables and investigations that give conjecture and consistency to the calculated values (Ponce et al., 2021; Buchheit, 2017 mentioned by Suarez et al., 2020) because in certain microcycles the acute loads presented are quite unusual; it would be the case of the MP, MTD, and MTE, where the risk of injury is increased.

A limitation of this study and the development of future research is to assess the chronic load and its relationship with the acute load throughout this period to detect possible exposures to unforeseen load peaks; in addition to weekly changes that identify sudden changes in its trend (Gabbett, 2016; Clemente et al., 2021). Currently, the use of

GPS is providing high quality information in the process of individualization of the SSP that allows the creation of a Dynamic Competitive Profile (Chena, 2021; Martín, 2019), but this technology is not available for all teams due to its economic cost.

When comparing training loads versus competition loads, the latter are always higher than the former, so we must make a reflection as coaches, physical trainers, and sports professionals in general to identify what are the mistakes we make for such an unbalanced balance.

Another reflection arises when we focus on the theoretical bases of the sciences of complexity in which this study and all those mentioned above are adjusted, as these state the constant intra and interrelationship that the dynamic system, athlete, suffers before what it is exposed to, variables and qualitative fluctuations that we intend to understand and determine under quantitative parameters. Possibly we are falling into the same mistake that was made when planning DIEC with individual sports. We need new research focuses.

Likewise, no comparative studies similar to this one have been found in the male gender.

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IMPACT OF RESISTANCE TRAINING IN CHILD AND YOUTH POPULATION: A SYSTEMATIC REVIEW

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Abstract. The aim of this study was to find out the resistance training influence on the child and adolescent population, as well as determine the possible risks or benefits that the training of this physical capacity may cause. A systematic review has been carried out on the impact of resistance training in subjects aged between 6 and 18 years. The studies used in this review were identified through Pubmed database, selecting those written in English or Spanish, from 2010 to the present. The revision was carried out between November 2020 and May 2021. A total of 328 articles were identified in the initial search, of which 20 articles were chosen for this systematic review. The results show that the benefits from resistance training clearly outweigh their risks, as long as the training program is supervised and guided by qualified personnel, individualizing the training loads to each subject need. Likewise, resistance training in young population contributes to the improvement of different motor skills and sports activities, resulting in an effective strategy for diseases such as obesity.

Keywords: Childhood, obesity, motor skill, children, exercise.

INCIDENCIA DEL ENTRENAMIENTO DE FUERZA EN LA POBLACIÓN INFANTOJUVENIL: REVISIÓN SISTEMÁTICA

Resumen. El objetivo de esta revisión fue conocer la influencia que tiene el entrenamiento de fuerza en la población infantojuvenil, además de buscar los posibles riesgos o beneficios que pueda ocasionar el entrenamiento de esta aptitud física. Se ha llevado a cabo una revisión sistemática de estudios de intervención sobre el impacto que produce el entrenamiento de la fuerza en sujetos con una edad comprendida entre 6 y 18 años. Los estudios utilizados en esta revisión se identificaron a través de la base de datos PubMed, seleccionando aquellos escritos en inglés o castellano, desde el 2010 hasta la actualidad. La revisión se efectuó entre los meses de Noviembre de 2020 hasta Mayo de 2021. Se identificaron un total

de 328 artículos en la búsqueda inicial, de los cuales 20 artículos fueron elegidos para esta revisión sistemática. Dentro de las principales evidencias encontradas, los beneficios derivados del entrenamiento de fuerza se imponen notablemente a los riesgos, siempre y cuando el programa de entrenamiento sea supervisado y pautado por personal cualificado, individualizando la carga a las necesidades de cada sujeto. Asimismo, el entrenamiento de fuerza en esta población contribuye a mejorar el rendimiento de distintas habilidades motoras y actividades deportivas, resultando además una estrategia eficaz ante patologías como la obesidad.

Palabras clave: Infancia, obesidad, habilidad motora, niños, ejercicio.

Introduction

The term strength training refers to a specialized method of conditioning, which involves the progressive use of resistant loads and a variety of training modalities designed to improve health, fitness, and athletic performance (Faigenbaum et al., 2009). Although strength training and weight training are often used as equal terms, the term strength training encompasses a broader range of training modalities and training goals (Faigenbaum et al., 2009).

Strength training in children and young people has been a subject that for many years has generated great controversy regarding the type of training, volume or duration, as well as numerous doubts as to its contribution to this population (Vrijens, 1978). With the passage of time, more research has been done on this subject and from the NSCA study (1985) possible benefits of this training have been found, reflecting improvements on the mastery of motor skills and generating a positive contribution on other abilities.

The physical health-related benefits of strength training for young people is another relevant issue. It has been shown that the implementation of an adequate strength program induces improvements in bone health and body composition, as well as being highly effective in preventing possible injuries, especially in sports (Faigenbaum et al., 2009).

With the right training methods, this type of training for children and adolescents can be relatively safe, leading to an improvement in overall health (Behm, 2008). In addition, another aspect that scientific evidence highlights is the need for supervision and prescription of this type of training by a professional, being key to the effectiveness of training programs, since prioritizing the physical safety of young people will be necessary for the improvement of health and performance (Loyd et al., 2014).

To this day there are still misconceptions about strength training in children that they are more prone to injury than adults. Not only do these notions appear to be incorrect, but children's response to strength training is actually quite similar to that of adults, although they do not gain as much muscle mass (Falk & Dotan, 2019). Under proper guidance and supervision, the incidence of strength training-related injuries is no higher in children than in adults. Strength training has other benefits for children beyond actual strength improvement. It can help reduce the risk of activity-related injuries in general, and especially in other sports. In overweight youth, it can also improve metabolic profile and help in the management of conditions such as diabetes (Falk & Dotan, 2019).

Regarding the prescription of the type of strength training and the development of the sessions in the infant and juvenile population, there are a variety of aspects to take into account, such as the volume of work or the intensity among other things. Given the disparity of methodologies with different types of exercises, there seems to be no ideal training model, although all agree that the training dose should be taken into

consideration, this being an important aspect to produce the desired effect (Lesinski et al., 2016).

Method

For the development of this review, a search was carried out in PubMed databases between November 2020 and May 2021. A review was made of publications from 2010 to the present. The search was performed following the *Preferred Reporting Items for Systematic reviews and Meta-Analyses* (PRISMA) review protocol, which consists of a 27-point checklist of the most representative sections of an original article (Liberati et al., 2009). The following keywords were used for the PubMed search: Physical activity AND Resistance training, Children AND Strength training, and Strength training AND Children AND Adolescents.

For the selection of the articles a series of inclusion criteria were taken into account: a) Intervention studies that evaluated the effect of a physical training program; b) Studies carried out in children over 6 years old up to 18 years old; c) Randomized and Non-Randomized samples; d) Studies that evaluate the positive effects of strength training; e) The languages selected for the search were English and Spanish.

On the other hand, the criteria chosen for exclusion were the following: a) Studies that did not evaluate the effects of regular physical exercise; b) Studies with adults; c) Clinical trials carrying out strength training programs in children with special needs.

In order to assess the scientific quality of the studies, the *PEDro* scale was used. This scale consists of 11 items, although the evaluation is given out of 10, since the first item is not taken into account in the rating. Scores between 9 and 10 are considered to be of excellent quality; between 6 and 8, of good quality; between 4 and 5, of fair quality and, finally, values lower than 4 mean poor quality.

Results

A total of 328 articles were identified in the initial search. After the first screening, 190 articles were eliminated, leaving 138 articles selected for full-text analysis. Finally, after exclusion of articles that did not meet the inclusion/exclusion criteria, 20 articles were eligible for this systematic review (Figure 1).

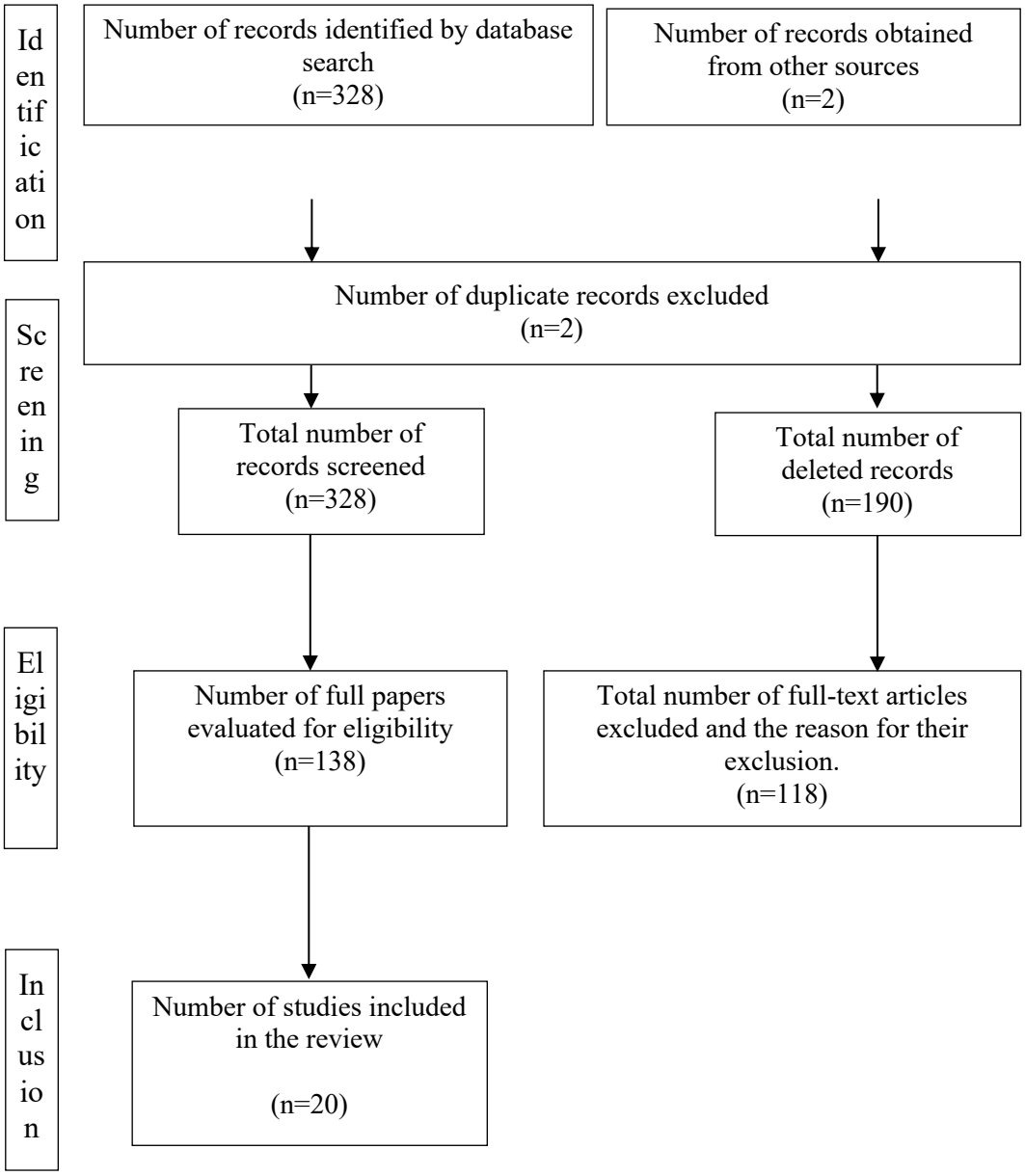

Figure 1. Flowchart

In total, 1461 participants (517 girls and 944 boys) were analyzed in the studies presented in this review. Table 1 describes the studies carried out, describing the type of training performed, the duration of the training programs, the weekly training sessions, and the main findings after the completion of the interventions. Of these, eight studies investigated the effect of strength training in the child-adolescent, athletic population (Rodriguez-Rosell et al., 2017; Panagoulis et al., 2020, Moran et al., 2018; Hopper et al., 2017; Piazza et al., 2014; Amaro et al., 2017; Negra et al., 2016; Parsons et al., 2017), five studies investigated the effect of strength training in obese subjects (Alberga et al., 2016; Goldfield et al., 2015; Monteiro et al., 2015; Schranz et al., 2014; Davis et al., 2011), and seven studies investigated the effect of strength training in the general infant and juvenile population (Pichardo et al., 2019, Meinhard et al., 2013; Granacher et al., 2011; Lee et al., 2012; Lloyd et al., 2016; Bernardoni et al., 2014; Deldin et al., 2019). In all studies, the strength training sessions were supervised by a professional strength expert, controlling in situ the appropriate training load for each subject in order to carry out progressive overload and avoid any type of poor execution or excessive load. The training methods varied among the studies, being able to observe great heterogeneity in the exercises carried out.

Table 1

Description of the intervention studies included in the systematic review.

STUDIO	SAMPLE	INTERVENTION	CONCLUSIONS
Pichardo et al. (2019)	59 children aged 12-14 matched by maturity. 2 groups. Group 1. Performance of combined strength training. N= 29. Group 2. Strength training combined with weight lifting. N= 31.	28 weeks. Sessions 2-3 times per week. Group 1 performed leg exercises, pushing exercises, and pulling exercises with a combination of exercises dedicated to plyometrics. While group 2 also performed strength and plyometric exercises, they substituted some weight lifting exercises for aerobic exercise.	There were no significant differences between the groups, but all variables improved significantly within the group. Both groups achieved small-to-moderate improvements after the first 14 weeks of training, increasing lower body power, upper body power, and speed. Both groups achieved small-moderate improvements in all performance variables after 28 weeks of training. Tests: Resistance Training Skills Battery Quotient (RTSQ), Isometric Mid-Thigh Absolute Maximum Strength Pull (IMTPABS), Isometric Mid-Thigh Pull in Maximum Strength Ratio Scale (IMTPREL), countermovement jump, horizontal jump, and 10 m, 20 m, and 30 m sprint.
Alberga et al. (2016)	304 children aged 14-18 years with body mass index ≥ 85th percentile. 4 groups. Group 1. Aerobic training program. N= 75. Group 2. Strength training program N= 78.	22 weeks. Sessions of a minimum of 40 minutes 2-5 times a week. Group 1 exercised on treadmills, cycloergometers, and treadmills. Group 2 performed a full-body workout consisting of 7 exercises.	Aerobic exercise training alone increased Endurance, while strength training only increased upper and lower body muscle strength. The greatest improvements in overall strength and fitness were demonstrated by combined aerobic and strength training. Aerobic training had the strongest effect on cardiorespiratory fitness.

	Group 3. Combined aerobic and strength training program. N= 75. Group 4. Control group that did not exercise. N= 76.	Group 3 trained a combination of the two previous groups aiming for the same volume and intensity. A graded treadmill stress test and a maximal strength test of different exercises were performed pre- and post-intervention. The training program was combined with a maximum daily energy deficit of 250 kcal to promote healthy eating.	
Rodríguez-Rosell et al. (2017).	86 male footballers between 13 and 17 years of age. 3 groups. Group 1. Football players under 13 years of age. N=30. Group 2. Football players under 15 years old. N=28. Group 3. Football players under 17 years of age. N=28. Once divided they were divided into two subgroups: a strength training group and a control group.	6 weeks. 2 workouts per week where we did squat on multipower, 5 max jumps with hands on hips, and 20 m straight line sprint drills. Maximal strength, vertical jump, and sprint were measured before and after.	Improvements in maximal strength, jump height, and sprint time were observed in the subjects, who performed the strength program, while no significant gains were found for any variable in the control group.

Goldfield et al. (2015)	304 adolescents aged 14-18 years with body mass (BMI) at or above the 95th percentile for age and sex or above the 85th percentile plus a cardiovascular risk factor. 91 boys and 213 girls divided into 4 groups. Group 1. Aerobic training. N= 75 (boys and girls). Group 2. Strength training. N= 78 (boys and girls). Group 3. Combined strength and aerobic endurance training. N= 75 (boys and girls). Group 4. Control group. N= 76 (boys and girls).	4 weeks. Gym training 4 times a week. The aerobic training group performed workouts that progressed gradually in exercise duration and intensity. The strength training group performed strength exercises using machines or free weights. The combined training group performed the full aerobic plus resistance training program. Pre- and post-intervention MRI and several tests on mood, body image, and self-esteem were performed. Mood was measured using the Brunel mood scale. Body image was assessed using the Multiple Body Self-Relationship Questionnaire, and physical self-perceptions and global self-esteem were measured using the Harter Physical Self-Perception Questionnaire.	Aerobic, strength, and combined training reduced total body fat and waist circumference in obese adolescents. In the most adherent participants, combined training may cause greater decreases than aerobic or strength training alone.
Monteiro et al. (2015)	48 obese subjects between 11 and 17 years old. 3 groups. Group 1. Aerobic training. 8 girls 10 boys. N=18.	20 weeks. 50-60 minute workouts 3 times per week in both groups. Group 1 sessions consisted of walking and running.	The benefits of exercise in reducing body fat and metabolic risk profiles can be achieved by performing any type of training in obese adolescents.

	Group 2. Carrying out concurrent training. 5 girls 9 boys. N=16. Group 3. Control group. 8 girls 8 boys. N=14.	Group 2 first performed strength sessions consisting of leg press, low rowing, bench press, squats, push-ups, push-ups, leg push-ups, push-ups, seated chest machine, triceps, leg extension, seated and supine trunk extension and then performed the same aerobic session as group 1 but for 30 minutes. Body fat percentage, fat-free mass, android fat percentage by DEXA, and other metabolic profiles were measured at baseline and after the interventions.	
Meinhard et al. (2013)	102 boys and girls between 10 and 14 years of age. 4 groups divided by the classes of the school year. Group 1. Intervention in children. N=32 Group 2. Intervention in girls. N=22 Group 3. Control in children. N=28 Group 4. Control in girls. N=20	19 weeks. Strength training twice a week. Seven multi-joint exercises in circuits of barbell back squat, barbell stride, fitball back extension, abdominal crunch, bench press with barbell, barbell, and press rowing Energy expenditure, leg and arm strength, and body composition were measured before the intervention after the intervention and 3 months after the end of the study.	Targeted strength training significantly increases spontaneous daily physical activity behavior in children. The least active children showed the greatest increase in energy expenditure. Girls showed a similar increase in strength but not in energy expenditure. This may be explained by their earlier pubertal development. Strength training may be a promising strategy in schools to counteract declining levels of PA. Leg and arm strength increased due to the training intervention in both boys and girls (a leg press for the lower body and a Smith machine for the upper body were used to reach these conclusions). In addition, body composition and kcals expended per minute were also measured.

Panagoulis et al. (2020)	28 prepubertal adolescent boys. 2 groups. Group 1. Control group. Participated only in conventional football training. N = 14 1(14 ± 0.57 years, Tanner stage 2. 8 ± 0.6) Group 2. Participated in neuromuscular integrative training in addition to conventional football training. N = 14 1(12 ± 0.5 years, Tanner stage 2.6 ± 0.5).	8 weeks. 3 neuromuscular training sessions per week. The protocol included the following exercises throughout the training: squat, Romanian deadlift, Bulgarian squat, Romanian deadlift with one leg, box jumps, and core exercises and then adding stability exercises and exercises with body weight. Speed, (10, 20 m), change of direction (COD), jumping performance and strength were measured before and after training.	An 8-week neuromuscular program can induce positive adaptations in the performance of early adolescent soccer players during the season, suggesting that neuromuscular training may be an effective training intervention for this age group.
Schranz et al. (2014)	56 obese children between 13 and 17 years old. 2 groups. Group 1. Strength training. N= 30. Group 2. Control group. N= 26.	6 months. 3 strength training sessions per week of 75 minutes. A total of 10 multi-joint exercises with guided machines and free weights. The exercises performed were bench press, leg press, pull-up, leg curl (lying or seated), shoulder press (seated), seated rowing, biceps curl, triceps extension, calf raise (seated), and abdominal contraction. Outcomes were assessed at 3 months, 6 months (just after the end of the trial), and 12 months.	A 6-month strength training intervention can positively affect the self-concept and strength of overweight and obese adolescents. The performed physical tests were maximum repetition in bench press on Smith machine and leg press. Both tests showed improvements in the intervention group compared to the control group.

Granacher et al. (2011)	28 boys and girls between 14 and 16.7 ± 0.6 years. 2 groups. Group 1. Participated in strength training program. 8 girls and 6 boys. N= 14. Group 2. Control group. 7 boys and 7 girls. N= 14.	8 weeks. 2 lower limb strength training sessions twice a week. Pre, post, and follow-up testing included measurements of static and quasi-dynamic postural control on balance platforms, analysis of VJH height on a strength platform, and assessment of maximal isometric leg extension strength (peak isometric strength and rate of force development on a leg press). Pre- and post-intervention measurements of maximal isometric strength and rate of strength development of leg extensors, vertical jump height (VJH), and assessment of static and dynamic postural control.	The results showed that the training could have an impact on improving the level of performance in various motor skills and sport activities in physical education.
Lee et al. (2012)	45 obese children between 13 and 16 years old. 3 groups. Group 1. Performed strength training program. N= 16. 14.6 ± 1.5 years Group 2. Performed aerobic training program. N= 16. 15.2 ± 1.9 years Group 3. Control group. N= 15.	3 months. 60 minutes of training 3 times per week in the aerobic training group with treadmills, elliptical, or bikes. 60 minutes of training 3 times per week in the strength training group. Each training session included leg press, leg extension, leg curl, leg press, chest press, lat pull down, seated rowing, biceps curl, triceps extension, push-ups, and sit-ups.	Both aerobic and strength training alone were effective in reducing abdominal fat and intrahepatic lipids in obese adolescent boys. Strength training, but not aerobic training, is also associated with significant improvements in insulin sensitivity. Changes in visceral fat were associated with changes in intrahepatic lipids and insulin sensitivity.

	14.8 ± 1.4 years	Fat loss, insulin sensitivity, and insulin secretion were measured before and after the trial without caloric deficit.	
Moran et al. (2018)	22 young male swimmers pre PHV (11.9 ± 1.2 years) and post PHV (15.0 ± 1.1 years). 4 groups Group 1. Pre PHV. N=14 Group 2. Post PHV. N=8 Group 3. Control pre PHV. N=15 Group 4. Post PHV control. N=7	8 weeks. 2 workouts per week, 30 minute sessions. The workouts were based on strength circuits that included goblet squats, push-ups, planks, glute bridges, and strides. Subjects performed physical fitness tests the week before and the week after the trial. Anthropometric measurements, jump test, and body mass. Specifically, a handgrip dynamometer to assess grip strength, a jumping mat to assess vertical jumping, and a portable pull cord to measure pulling capacity were used to measure the tests performed on the subjects.	The results of this study show that strength training can improve performance in both pre and post PHV swimmers, showing greater benefits in post PHV swimmers.
Hopper et al. (2017)	23 female netball players aged 12.17 ± 0.94 years. 2 groups. Group 1. Performed neuromuscular training. N= 13.	6 weeks. 3 non-consecutive workouts per week of approximately 1 hour. The sessions were divided into two parts, one part of different plyometric exercises and another part of strength exercises, where the	The intervention significantly improved sprinting, change of direction speed, vertical jumping, and movement in 11-14 year old netball players. The control group showed no significant improvement in any of the physical performance measures or movement competence assessments over the course of the 6-week intervention.

	Group 2. Control group. N= 10.	following exercises were combined throughout the 6 weeks: back squat, front squat, inverted pull-ups, supine pull-ups, barbell rowing, incline bench press, bench press, Romanian deadlift, strides, and military press. They completed a battery of tests before and after the VJH and PAR-Q intervention.	After completion of the 6-week neuromuscular program, the data revealed that the intervention group performed significantly better than the control group in all physical performance tests.
Piazza et al. (2014)	57 rhythmic gymnasts 12.0 +/- 1.8 years. 3 groups. Group 1. Non-specific strength training with dumbbells. N= 19. Group 2. Performed specific strength training with weighted belts. N= 18. Group 3. Performed non-specific strength training. N= 20.	6 weeks. 3 sessions per week. Group 1 carried out a training program based on the execution of squats and variations of these with dumbbells. Group 2 performed a training program based on back strides, power skips, strides, skipping, and jumps. The following pre- and post-intervention tests were performed: squat jump test, countermovement jump test, jump test, hip flexibility, and anthropometric measurements.	Both non-specific and specific strength training positively affected jumping performance with an increase in lower extremity explosive strength of 6-7%, with no side effects. The flight time of the countermovement jump increased significantly, while the ground contact time of the jump test decreased significantly. No significant differences between groups were detected for flexibility, body mass, calf, and thigh circumference. Therefore, six weeks of strength training integrating different elements of rhythmic gymnastics training improves jumping ability in young female athletes.
Lloyd et al. (2016)	80 school-aged children were categorized into 2 maturity groups (pre- or post-PHV) and then randomly assigned.	6 weeks. Training twice a week. Group 1 included barbell back squats, barbell lunges, dumbbell step ups and leg presses in their workouts, group 2 performed a battery	Plyometric training made the greatest gains in all performance variables in pre-PHV children, while combined training was the most effective in eliciting changes in all performance variables for the post-PHV cohort. The study indicates that plyometric training may be more effective for short-term gains in jumping and sprinting in children who are pre-PHV.

	4 groups which in turn are divided into 2 (pre or post PHV). Group 1. Performed traditional strength training. N= 20. Group 2. Performed plyometric training. N= 20. Group 3. Performed combined strength and plyometric training. N= 20. Group 4. Control group. N=20.	of jumping and landing mechanics exercises, and group 3 performed 2 plyometrics exercises from group 2 and barbell squats and lunges. Acceleration, maximal running speed, squat jump height, and reactive strength index data were collected before and after the intervention.	
Amaro et al. (2017)	21 prepubertal male swimmers aged 12.7 ± 0.8 years with at least 2 years of competitive swimming experience and no previous strength training experience. 3 groups. Group 1. Performance of the series by number of repetitions. N= 7. Group 2. Performance of the series by time in seconds. N= 7. Group 3. Control group. N= 7.	10 weeks. 2 sessions per week. Mean strength, mean mechanical impulse, vertical jump, mean ball throwing values, and crawl swimming performance were assessed pre-intervention after 6 weeks of the program and after 10 weeks.	Significant improvement in the performance in swimming crawl style and especially in the 50 m race with group 2 showing greater improvements. As for the vertical jump, an improvement was observed in groups 1 and 2. Regarding ball throwing, a significant improvement was observed in group 2. On the other hand, it was observed that strength and mechanical impulse did not show an improvement effect.

		12 weeks.	
Negra et al. (2016)	24 male soccer players aged 12.7 ± 0.3 years. 2 groups. Group 1. Performed 3 weekly sessions of football specific training and 2 sessions of high speed strength training. N= 13. Group 2. Control group. They carried out 5 weekly sessions of specific football training. N= 11.	2 sessions per week of 80-90 minutes on average. Pre- and post-training tests were carried out to evaluate muscle strength, jumping ability, linear speed, and change of direction by means of different tests. Specifically, pre- and post-tests included a maximal strength test in half squat, squat jump and countermovement jump, evaluation of 5 consecutive jumps, long jump test, linear sprint test, The Illinois change of direction test, and The T test to evaluate change of direction.	Improvements were observed in the group that carried out the high speed strength training program: Significant increases in half squat performance. Increased jumping performance, increasing the values in the vertical jump. Increased 10 m sprint performance. However, no significant improvements were seen in the direction change tests.
		7 months.	
Bernardoni et al. (2014)	45 girls aged 11 to 12. 2 groups. Group 1. 2-3 strength training sessions in the physical education sessions. N= 22. Group 2. Control group. 2-3 sessions of conventional physical education per week. N= 23.	2-3 strength training sessions per week on non-consecutive days. The strength training was based on circuits that included exercises with body weight, resistance bands, and dumbbells where the whole body was worked. Pre-intervention and post-intervention whole body and regional DXA scans were performed using a GE Healthcare Lunar iDXA densitometer to measure bone mineral content, bone mineral density, non-bone fat free mass, and fat mass.	The school-based strength training intervention produced maturity- and region-specific bone gains in adolescent girls. Strength training may be a good osteoporosis prevention strategy for adolescent girls.

		16 weeks.	
Davis et al. (2011)	38 adolescent girls (15.8 ± 1.1 years) with overweight/obesity. 3 groups. Group 1. Aerobic training + strength. N= 14. Group 2. Aerobic training + strength + motivational interviewing behavioral therapy. *N*= 12. Group 3. Control group. N = 12.	2 sessions of 60-90 minutes per week, (30-45 minutes of cardiovascular activity along with a total of 30-45 minutes of strength training per workout). Group 2 also received four individual motivational interviewing sessions and four group sessions throughout the program. The exercises included in the strength circuits were leg press, quadriceps extension on machine, triceps extension, abdominal plank, abdominal crunch, squat, shoulder press on machine, heel raises, biceps curl, bench press, hamstring curl, high pull-up rowing, rowing machine.	Participants in group 1 and 2 compared to the control group significantly increased their physical fitness. Results were also seen in decreases in waist circumference, subcutaneous adipose tissue, visceral adipose tissue, fasting insulin, and insulin resistance.
Parsons et al. (2017)	40 female athletes aged 10-14 years of which 36 completed the study. 2 groups. Group 1. Strength training focused on the lower body. N= 19. Group 2. Strength training focused on the upper body. N= 17.	12 weeks. 2 training sessions of 1 hour per week. Strength training based on exercises with your own body weight and free weights. The exercises performed by group 1 were squat, lunges, glute abduction, and hamstring curl with glides. The exercises performed by group 2 were chest press, biceps curl, shoulder press, and dumbbell rowing.	There was no difference between groups on the improvement of landing jumping skills.

Deldin et al. (2019)	28 boys and 27 girls between 12 and 18 years old. 2 groups. Group 1. Strength training. N = 14 boys and 14 girls. Group 2. Aerobic training. N= 14 boys and 13 girls.	3 months. Group 1. 80 minutes per week of strength training. Group 2. 80 minutes per week of aerobic training. The strength training performed by group 1 included exercises with guided machines and worked all muscle groups. Tests to determine participants' physical capacity included a treadmill test to assess cardiorespiratory fitness and a leg press and chest press test with one repetition maximum, in addition to receiving hematological and biochemical tests before and after the trial.	With the exception of abdominal SAT, there were no treatment differences by sex or exercise in total and regional fat reductions. In response to strength training, increases in total and regional skeletal muscle were significantly greater in boys than in girls.

Note: PHV = PHV = Peak height velocity; PA = Physical Activity; SAT= Subcutaneous adipose tissue

Table 2 shows the methodological quality of the articles reviewed with a rating range from 6/10 to 9/10 on the PEDro scale.

Table 2
PEDro scale results

AUTHORS (YEAR)	1	2	3	4	5	6	7	8	9	10	11	TOTAL
Pichardo et al. (2019)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	9
Alberga et al. (2016)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	9
Rodríguez-Rosell et al. (2017).	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	7
Goldfield et al. (2015)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Monteiro et al. (2015)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	9
Meinhard et al. (2013)	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	7
Panagoulis et al. (2020)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Schranz et al. (2014)	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	7
Granacher et al. (2011)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Lee et al. (2012)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Moran et al. (2018).	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	7
Hopper et al. (2017)	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	7
Piazza et al. (2014)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Lloyd et al. (2016)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Amaro et al. (2017)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Negra et al. (2016)	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	7
Bernardoni et al. (2014)	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	8
Davis et al. (2011)	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	6
Parsons et al. (2017)	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	6
Deldin et al. (2019)	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	7

Discussion and conclusions

Over the last few years there has been controversy about strength training and children, about the possible effects on both performance and development. Strength training could have an impact on improving the level of performance in various motor skills and sporting activities in physical education, as well as being a promising strategy in schools to counteract decreasing levels of physical activity (Meinhard et al., 2013).

Comparisons have been made between strength training and aerobic training (Pichardo et al., 2019; Alberga et al., 2016; Lee et al., 2012; Goldfield et al., 2015), where

the benefits of the different trainings are tested. Both types of training seem to have significant improvements in terms of power (Pichardo et al., 2019), being the aerobic training where greater benefits were found at cardiorespiratory level (Alberga et al., 2016). Other authors (Goldfield et al., 2015) mention that where they find greater benefits in fat loss is in a type of training that combines both types of skills. However, other authors find benefits related to insulin sensitivity in strength training (Lee et al., 2012).

Strength training can also be performed as an anti-obesity strategy (Alberga et al., 2016; Goldfield et al., 2015; Monteiro et al., 2015; Schranz et al., 2014; Lee et al., 2012; Davis et al., 2011). In comparing different types of training, Goldfield et al. (2015) observed how both aerobic, strength, and combined training reduced total body fat and waist circumference in obese adolescents. Following this same line, it has been seen that metabolic risk profiles can be achieved by performing any type of training in obese adolescents (Monteiro et al., 2015). Another research by Schranz et al. (2014) showed that training can positively affect self-concept in addition to strength in overweight and obese adolescents. Finally, it is highlighted that programmed training can become an excellent tool for the improvement of cardiorespiratory health (Alberga et al., 2016).

Some clinical trials wanted to observe the effects of training in different sports such as football (Rodriguez-Rosell et al., 2017; Panagoulis et al. 2020; Negra et al., 2016), swimming (Moran et al., 2018; Amaro et al., 2017), rhythmic gymnastics (Piazza et al., 2014), or netball (Hopper et al., 2017). The contribution of Rodriguez-Rosell et al. (2017) related to strength and football showed benefits in maximal strength, vertical jump, and sprint time compared to the control group. On the other hand, Negra et al. (2016) showed benefits in the half squat and, as in the previous study, in jumping and sprinting. Meanwhile, Panagoulis et al. (2020) established that neuromuscular training can induce positive adaptations in the performance of early adolescent soccer players during regular season. Regarding swimming, Moran et al. (2018) seem to find improvements in body composition, vertical jump, and anthropometric measurements, while the study by Amaro et al. (2017) mentions that they found improvements in swimming crawl style especially in 50 meters as a result of strength training. Likewise, the relationship of strength training and rhythmic gymnastics was shown with increased jumping performance and an increase in lower extremity explosive strength of 6-7%, with no side effects (Piazza et al., 2014). In a less common sport such as netball, we also wanted to evaluate the influence of strength training, observing an improvement in sprinting, change of direction, and high jump as a result of strength training (Hopper et al., 2017).

Regarding strength training as a function of gender, Meinhard et al. (2013) wanted to make a comparison of strength training in boys (10-14 years) and observed that girls showed a similar increase in strength, but not in energy expenditure, which they do not attribute all the credit to this type of training but may also be explained by their earlier pubertal development. Another research that compared strength training as a function of gender was that of Deldin et al. (2019), who allude that strength training produced significantly greater increases in total and regional skeletal muscle in boys than in girls.

Within physical education in the school setting, strength training could also have a place, showing that it could have a positive impact on improving the level of performance in various motor skills and sporting activities (Granacher et al., 2011). Lloyd et al. (2016) did a study where they evaluated strength training, plyometrics training, and a combined training in school-aged boys and girls pre and post their peak performance velocity (PHV). The authors mention that it was the plyometrics training where the pre-PHV children made the greatest gains in all performance variables, while the combined training was the most effective in eliciting changes in all performance variables for the post-PHV cohort, in both cases speaking over a short period of time (Lloyd et al., 2016).

Other authors such as Davis et al., (2011) also relied on school girls for their intervention, where they showed a decrease in waist circumference, subcutaneous adipose tissue, visceral adipose tissue, fasting insulin, and insulin resistance, thus significantly improving their fitness. In addition, strength training may be a promising strategy in schools to counteract decreasing levels of physical activity (Meinhard et al., 2013).

In terms of improvement in landing jumping skills, there was no difference between groups on improvement following an intervention comparing lower body focused strength training and upper body focused strength training in female athletes (Parsons et al., 2017).

In this review we have found some limitations that are set out below: studies with a short duration of time. The time period of the interventions is different and generally short, with interventions lasting 7 months and interventions lasting only 4 weeks. In addition, the authors use different training methods, which makes it difficult to make a proper comparison and to know which methodology offers the best results. On the other hand, most of the investigations (n=8) analyzed strength training in comparison to other types of training and as many (n=8) to see the performance of this type of training within a specific sport, and very few (n=4) chose to analyze strength directly. The age of the children is very different from one study to another, there being significant differences in their maturation, many of the improvements obtained could be due to the maturational development. Similarly, the sample of more than half of the studies included (n=12) is less than 50, which may be too small to extract results.

After reviewing the studies analyzed, it can be concluded that strength training in the infant and juvenile population is an effective and safe strategy to contribute to improving strength parameters and general physical health, thus clarifying the possible doubts of the population as to whether or not strength training is beneficial. Regarding the method and strength exercises proposed, heterogeneity has been found among the different works analyzed, with no clear consensus among them and showing that some types of exercises are not better than others, being the key to progress the individualized progressive overload. In addition, another important part of strength training in children and adolescents is that it does not generate negative impacts on health, both physical and psychological; being a great ally to combat pathologies such as obesity, generating a good physical preparation for young athletes, and can contribute positively to school physical education. Future interventions in this type of population are recommended, carrying out more programs of only regular strength training in order to clearly demonstrate the benefits of strength training, since many studies combine it with aerobic training, which can make it difficult to clarify that the improvements obtained are mainly caused by strength training.

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INTENSITY, FREQUENCY AND DURATION OF PHYSICAL ACTIVITY DURING THE PANDEMIC IN ECUADOR

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Abstract. The aim of this research is to define the intensity, frequency, and duration of physical activity that respondents engage in to determine possible effects on overall health in the medium and long term. For this purpose, a quantitative approach research, non-experimental and cross-sectional design is carried out. With a mixed sample (probabilistic and non-probabilistic), composed of n=303participants, over 18 years old, selected by convenience. The instrument used is the "International Physical Activity Questionnaire" (IPAC), a short version consisting of 7 questions, preceded by 3 questions on the socio-demographic composition of the participants. Among the main results, 74.9 per cent of the respondents were teachers and16.8 per cent were administrative; 35 per cent had not engaged in intense or moderate physical activity; and 83.9 per cent had sat for 4 to more than 10 hours a day (24.1 per cent between 4 and 6 hours; 22.8 percent between 7 and 8 hours; 19.5 per cent between 9 and 10 hours; and 17.5 per cent for more than 10 hours). In conclusion, a probable relationship could be established between confinement and decreased physical activity; and between confinement and the number of hours that respondents have been seated. In addition, some medium- and long-term effects on the overall health of the participants (and all those who fit the characteristics of the study) could be assumed from physical inactivity and prolonged sitting time.

Keywords: physical activity, Covid-19, integral health, physical inactivity.

INTENSIDAD, FRECUENCIA Y DURACIÓN DE LA ACTIVIDAD FÍSICA DURANTE LA PANDEMIA EN ECUADOR

Resumen. La presente investigación se propone definir la intensidad, la frecuencia y la duración de la actividad física que practican los encuestados para determinar posibles repercusiones sobre la salud integral, a mediano y largo plazo. Con esta finalidad se realiza una investigación de enfoque cuantitativo y diseño no experimental, transeccional. Con una muestra mixta (probabilística y no probabilística), integrada por n=303 participantes, mayores de 18 años, seleccionada por conveniencia. El instrumento aplicado es el "Cuestionario Internacional de Actividad Física" (International Physical Activity Questionnaire = IPAQ),

versión corta, compuesto por 7 preguntas, precedidas por 3 preguntas sobre la composición sociodemográfica de los participantes. Entre los principales resultados se destaca que el 74,9% de los encuestados son docentes y el 16,8% administrativos; que el 35% no ha practicado actividad física intensa o moderada; y que el 83,9% ha permanecido sentado de 4 a más de 10 horas diarias (24,1%, entre 4 y 6 horas; 22,8%, entre 7 y 8 horas; 19,5%, entre 9 y 10 horas; y 17,5% más de 10 horas). Como conclusión se podría establecer una probable relación entre confinamiento y disminución de la actividad física; y entre confinamiento y el número de horas que han permanecido sentados los encuestados. Además, se podrían presumir algunas repercusiones, a mediano y largo, sobre la salud integral de los participantes (y de todos los que se ajusten a las características del estudio), derivadas de la inactividad física y de la prolongada cantidad de tiempo que permanecen sentados.

Palabras clave: Actividad física, Covid-19, salud integral, inactividad física.

Introduction

The discovery of Sars Cov-2 in December 2019 in Wuhan, China and the declaration of pandemic by the World Health Organization in March 2020 have changed the logic and functioning of the world beyond the dominant globalization (Herrero, 2020) and populist political trends (Tertrais, 2020). Since then, humanity faces an epidemic that, at times, has proved uncontrollable (Sianes & Sanchez, 2021) in a historical period of extremely high scientific and technological development (Alonso, 2019). As is evident, its effects can be seen in the most diverse areas of daily life: health, economic, psychological, social, educational, among others. In the field of public health, the pandemic has highlighted profound inequalities in coverage between rich and poor countries, and although at certain times the pandemic has focused on various regions of the world, a direct relationship between public spending on health and the number of deaths from Covid 19 has been pointed out (Barrera, Estepa, Sarasola & Vallejo, 2020); in addition, a probable reduction in the public health budget in several countries of the world before the pandemic has been denounced (Luján & Minassian, 2020). In the economic field, the consequences of the pandemic are numerous and substantial: loss of millions of jobs, bankruptcy of thousands of companies throughout the world, trade deficit and fiscal deficit in most countries, fall in exports (Mackay, León, & Bedor, 2020); among the main economic activities affected are tourism, trade, and the world's production and supply chains (Clavellina, 2020); in addition, ECLAC/ILO (2020) has projected a recession in the region of -5.3%. In the psychological field, the following effects on the world population have been mentioned: anxiety, insomnia, fear, uncertainty, frustration, excess of information, loneliness, sadness, and depression (Cabrera, 2020; Sandín, Valiente, García & Chorot, 2020). In the social field, the problems and inequality of vulnerable groups: unemployed, migrants, women, the elderly, etc., will become more acute (ECLAC, 2020; Sandín, Valiente, García & Chorot, 2020). (ECLAC, 2020). In the educational field, the pandemic has revealed the existence of a digital and technological gap between countries and families with resources and those without (UNICEF, 2021). In addition, it has highlighted the gaps in methodological, didactic, and technological training of teachers (Acevedo, Argüello, Pineda & Wurcios, 2020; García & Taberna, 2021), and the numerous problems that teachers and students may suffer due to confinement and the need to maintain social distancing. Despite the importance of each of the aforementioned domains, the present research focuses on the relationship between physical activity and covid 19.

The World Health Organization (2020) has emphasized on multiple occasions the importance of physical activity in maintaining people's health. While physical activity contributes to the prevention of some non-communicable diseases (cardiovascular diseases, cancer, and diabetes) and to the improvement of the physical, psychological, and mental well-being of individuals, physical inactivity could cause or aggravate numerous pathological conditions. Physical activity could prevent up to five million deaths per year. Moreover, WHO (2020) notes that 1.4 billion adults, aged 18 to 64 years, have not exceeded the minimum thresholds of physical activity: 150 to 300 minutes of moderate aerobic physical activities per week; or, 75 to 150 minutes of intense aerobic physical activities per week. Finally, WHO (2019) has revealed worrying figures on the insufficient physical activity of adolescents between 11 and 17 years of age, above 70%, and in extreme cases, above 90%. In relation to the aforementioned data, which reflect the global reality prior to the pandemic, it is suspected that those figures could have worsened during the 2020-2021 period. In this regard, there are some studies that point out that health prevention measures, introduced after the pandemic, could have reduced the time devoted to physical activity and exercise, with the consequent physical deconditioning (Mera, Tabares, Montoya, Muñoz & Monsalve, 2020); to the possible psychological and social effects of the lack of physical activity on the population (Camacho, Camacho, Merellano, Trapé & Brazo, 2020; Celis, Salas, Yáñez & Castillo, 2020); the need to implement cardiac rehabilitation programs to counteract the effects of social isolation during the pandemic (Carrillo, 2020); the need to maintain good levels of physical activity to reduce the risks associated with Covid-19 infection (Celis, Salas, Yáñez & Castillo, 2020); to the effects of physical activity for the preservation of mental, neuromuscular, cardiovascular, metabolic, and endocrine health of the population (Baena, Tauler, Aguiló & García, 2021); to the need to consider personal levels of physical activity as a vital sign during medical consultation (Márquez, 2020).

Due to the prolonged period of confinement and the demands of social distancing, it is possible to presume a decrease in physical activity, with a parallel increase in sedentary lifestyle, an increase in the consumption of carbohydrates and alcohol, a decrease in hours of rest, among others, which in the medium term could generate numerous consequences for the integral health of people (Mera, Tabares, Montoya, Muñoz, D. & Monsalve, 2020; Camacho, Camacho, Merellano, Trapé & Brazo, 2020; Celis, Salas, Yáñez & Castillo, 2020 ; Bravo, Kosakowski, Núñez, Sánchez & Ascarruz, 2020; Villaquirán, Ramos, Jácome & Del Mar, 2020; Rico, Vargas, Poblete, Carrillo, Rico, Mena, Chaparro & Reséndiz, 2020; Flores, Coila, Ccopa, Yapuchura, & Pino, 2021). And, although the definition of integral health includes all dimensions of the human being, for the purposes of this research, physical activity has been considered as its foundation. In this regard, it should be emphasized that physical inactivity represents the fourth risk factor for death in the world and that studies link it to certain types of cancer (breast and colon), diabetes, and ischemic heart disease (Márquez, 2020). Finally, Márquez (2020) recalls that 60% of the world's population does not practice the necessary amount of physical activity for health and that the percentage of physical inactivity is increasing in several rich countries and in some regions of the world, such as Latin America and the Caribbean.

Some studies related to the research variables are mentioned below. Pérez, Gianzo, Hervás, Ruiz, Casis, Aranceta, & the Collaborative Group of the Spanish Society of Community Nutrition (2020), in the article "Changes in dietary habits during the period of confinement for the COVID-19 pandemic in Spain," set out to analyze changes in dietary habits and other lifestyles during the period of confinement in a population group

in Spain. This is a cross-sectional, observational study conducted on a sample of 1036 people over 18 years of age recruited during weeks 6-8 of the Spanish confinement (April 21 - May 8, 2020). The results highlight that the most frequent changes refer to increased consumption of fruit (27%), eggs (25.4%), legumes (22.5%), vegetables (21%), and fish (20%); and reduced consumption of processed meats (35.5%), lamb or rabbit (32%), pizza (32.6%), distilled alcoholic drinks (44.2%), sugary drinks (32.8%), or chocolate (25.8%), with some differences mainly depending on age and the degree of adequacy of the usual diet. Some 14.1%, who usually do not cook, do so during this period. 15% do not do physical exercise, 24.6% spend more than 9 hours a day sitting, and 30.7% of smokers (14.7%) smoke more. Thirty-seven percent reported not sleeping well. Among the conclusions, it is mentioned that the participants in this study report dietary changes during the period of confinement in Spain, with a tendency towards greater consumption of healthy foods, less consumption of foods of less nutritional interest, and an increase in the practice of cooking at home.

Severi & Medina (2020), in the article "Changes in eating habits and physical activity during physical isolation during COVID-19: descriptive study on a sample of workers (Uruguay, April 2020)," aimed to identify changes in behavior regarding eating and physical activity in the health emergency, in a convenience sample of 170 workers, out of a cohort of 2091. A 17-question closed-ended telephone survey was administered on changes in eating and physical activity during confinement of workers and some associated factors. Sociodemographic characteristics were studied, such as sex and age, modality of work, distance, on-call, alternate days of attendance, and family structure of the household with at-risk populations such as children and people over 65 years of age. Weight and height were recorded by self-report, perception of weight variations, modifications in their routines and eating habits. Among the results, one third of the workers (30.6%) perceived weight increase and changed their behavior, almost 47% stated that they ate more frequently. Regarding the type of food, most of them reported an increase in carbohydrate-rich and ultra-processed foods. Of the 170 respondents, only 57 (33.5%) engaged in physical activity during the pandemic, in contrast to the 129 (75.9%) who did so before the pandemic (a reduction of 42.4%). In most of the homes there are children living together, which generates an obesogenic environment that increases the risk of excess weight in the short and medium term. It is concluded that there are unhealthy changes in eating behavior and physical activity that promote the risk of chronic noncommunicable diseases. It is suggested to take measures that complement those that seek to contain the transmission of the coronavirus in the community.

Sudria, Andreatta, & Defagó (2020), in the article "The effects of the coronavirus quarantine (Covid-19) on food habits in Argentina," attempt to analyze food consumption during the quarantine period in Argentina. To this end, they have developed an observational, exploratory, and cross-sectional study. Two survey questionnaires were designed to be completed in online format, one for the meat consuming population (PC) and the other for the vegetarian population (PV). Multiple-choice questions were included on sociodemographic characteristics, self-reported weight and height, history of chronic diseases, habitual food intake, and their perception of modification during the period of social isolation. Twelve days after the quarantine was decreed, a first cut in the data collection was made to perform a descriptive analysis. The non-probabilistic sample consisted of 2518 people who answered the form (2201 PC and 317 PV). A change in dietary habits was observed during the confinement period in both groups, mainly characterized by a decrease in the consumption of foods with immunomodulatory potential such as fruits and vegetables and an increase in the intake of discouraged foods

such as baked goods, sweets, sugary, and alcoholic beverages. On the other hand, 79% PC and 80% PV indicate that the pandemic has affected their lifestyle, especially in food consumption and physical activity. Among the conclusions, the impact on lifestyle and specifically on food since unhealthy diets could increase susceptibility to COVID-19 and affect recovery stands out.

Ríos & Walteros (2020), in their master's thesis "Intention towards physical activity in the adult population: before and after 4 months of social confinement due to the COVID-19 pandemic," wish to determine the intention towards physical activity in the adult population before and after 4 months of social confinement. A cross-sectional study was carried out in a sample composed of 812 people over 18 years of age from the departments of Atlántico, Bolívar, Cesar, Magdalena of Colombia. The interviews were conducted by telephone using a survey based on the Prochaska-Diclemente Transtheoretical model that measures the stages of change towards physical activity. The survey contains questions on the sociodemographic characteristics of the subjects such as: age range of the respondent, sex, educational level, socioeconomic stratum, type of health insurance, and area of work. The statistical package used for the statistical analysis was SPSS software version 24.0. To determine the intention towards physical activity before and during the 4 months of mandatory confinement, the chi-squared test was performed. The results show that 50.5% of the participants were male. In the Preparation stage, the study subjects showed a great difference since the percentage doubled after quarantine from 11.6% to 24.1%, followed by the number of people in the action and maintenance stages, which showed a reduction in the practice of physical activity after 4 months of the pandemic from 11% to 9.1% and from 24% to 16.5% successively. With respect to the intention to perform physical activity according to the role played in the household, men (62.5%) have a greater intention to perform physical activity after 4 months of the pandemic in the Action and Maintenance stage compared to women (46.4%). The following conclusions stand out: Precontemplation to perform physical activity had a slight change after quarantine, as it increased slightly. Next, the Preparers, i.e., people with the intention to start physical activity in the next few days doubled in percentage, this compared to those who had the same intention before starting the quarantine. On the other hand, the number of people who performed regular physical activity presented a reduction of up to one third in those who practiced physical activity before the quarantine with those who practiced it afterwards. In the same way, according to the role played in the household varies, a reduction is clearly observed in women with plans to practice physical activity before quarantine with those with the same intention after quarantine; while, on the contrary, men showed a greater tendency to practice regular physical activity after the quarantine period.

Cabrera (2020), in the review article "Physical activity and psychological effects of confinement by Covid-19," seeks to make a reflective analysis on the psychological effects caused by quarantine in humans and how routines are sought to reduce these effects, through the practice of physical activity at home. Bibliographic research focused on the subject of psychological effects and their mitigation through exercise and physical activity was carried out. In parallel, such research focused on the training plans disseminated by the media, digital platforms, and the internet. The data collected from the internet were the subject of reflection and discussion, and searches were conducted in Pubmed, Web of Science databases, among others. Among the psychological effects, the following stand out: anxiety, fear, uncertainty about the future, fears of infection, frustration, boredom, loneliness, feeling of receiving inadequate supplies, inadequate information, financial losses, and stigma. In children, regression to previous stages,

aggressiveness, and rebelliousness may be observed; in addition, they will show behavioral and emotional regulation problems. Some researchers have suggested long-lasting effects, even up to three years after quarantine from the virus (SARS). Some research suggests that longer quarantine durations are specifically associated with poorer mental health, post-traumatic stress symptoms, avoidance behaviors, and anger. Brooks et al. (2020) conclude that the psychological effect of quarantine is broad, substantial, and long-lasting, yet it is advisable as a means of containment. Psychologists advise the practice of daily routines to avoid the psychological toll caused by social isolation. Among the conclusions, it is noted that there are not many studies to evaluate the psychological sequelae of COVID-19 quarantine; however, some investigations present maintenance physical activity and recreational activities as an excellent tool to combat the psychological effects of confinement.

The present research aims to define the intensity, frequency, and duration of the physical activity practiced by the respondents in order to determine possible repercussions on integral health in the medium and long term. Above all, it seems relevant to highlight the amount of time the interviewees spent sitting on a daily basis, in contrast to the physical activity performed. To this end, the International Physical Activity Questionnaire has been selected to determine possible impacts on integral health in the medium and long term. This provides a valuable input for further research to consider the differences between physical activity before and during the pandemic, and to determine possible consequences on the various areas of people's overall health (physical, emotional, and social). Its relevance lies not only in the evident topicality of the subject, aggravated by the characteristics of the pandemic but above all in the discussion of a problem that is currently little addressed - due to the urgency of scientists and pharmaceutical companies, focused on the creation of vaccines and the inoculation of the world population - and whose effects will become evident in the medium and long term.

Method

Design

To address the study problem, the quantitative approach is used, with a non-experimental, transect design (Hernández, Fernández, & Baptista, 2014).

Participants

For the present study, a mixed sample (probabilistic and non-probabilistic) of (n=303) participants, over 18 years of age, selected by convenience, was used. Among the first group are teachers and administrative staff of a prestigious institution of higher education, who were invited to participate in the survey through the institutional web page; while the second group is composed of various professionals who teach and participate in various master's degree programs, contacted by the research team by e-mail. Although the participating subjects did not sign an informed consent form, they all agreed to participate voluntarily in the research.

Instrument

For the development of the research, the "International *Physical Activity Questionnaire*" (IPAQ) was used, which has been catalogued as a suitable instrument to survey the physical activity of a given group (Mantilla & Gómez, 2007). The short version of the IPAQ (Carrera, 2017) consists of seven questions that allow assessing the intensity,

frequency, and duration of physical activity, with a reliability of 0.65% (Mantilla & Gómez, 2007). In relation to intensity, a distinction is made between mild, moderate, and intense; while in the field of frequency, the number of days per week is established; finally, duration, it is set in the amount of time of physical activity performed each day. The seventh question of the questionnaire asks about the number of hours that the respondents remained seated during a day. The questionnaire is preceded by three questions that make it possible to establish some sociodemographic characteristics of the population, such as sex, age, and profession or occupation of the respondents.

For the application of the instrument, a Google forms form was used, the link to which was provided through the aforementioned means. The form was available from May 13 to July 24, 2021.

Data analysis

The general principles of descriptive statistics were used for data analysis. With the information obtained through the Google forms program, we proceeded to the construction of four tables that summarize numerically the main variables addressed in the study: sociodemographic characteristics of the participants, time spent in physical activity by levels (intense, moderate, and walk), levels of physical activity (intense moderate, and walk), and time spent sitting during a day. And on that basis, some significant figures have been highlighted and will be discussed in the following section.

Results

The results of the application of the International Physical Activity Questionnaire, summarized in tables, are presented below.

Table 1
Sociodemographic characteristics of the participants

Sex	**No.**	**%**	**Age Ranges**	**No.**	**%**	**Profession or occupation**	**No.**	**%**
Man	112	37%	18-25 years	9	3%	Teacher	227	74,9%
Woman	191	63%	26-30 years	34	11,2%	Administrative	51	16,8%
			31-35 years	54	17,8%	Student	8	2,6%
			36-40 years	46	15,2%	Others:	17	5,7%
			41-50 years	86	28,4%			
			Over 50 years	74	24,4%			

Table 1 Sociodemographic characteristics of the participants contains information on the sex, age ranges, and profession or occupation of the respondents. It should be noted that 63% of the participants are women and 37% men, 52.8% are over 41 years of age, 74.9% are teachers, and 16.8% are administrators in educational institutions.

Table 2
Time spent on physical activity by level

Intense			Moderate			Walk		
Time	No.	%	Time	No.	%	Time	No.	%
0	106	35%	0	107	35,3%	0	40	13,2%
10-20 min	31	10,2%	10-20 min	48	15,8%	10-20 min	64	21,1%
20-30 min	39	12,9%	20-30 min	42	13,9%	20-30 min	65	21,5%
30-40 min	30	9,9%	30-40 min	33	10,9%	30-40 min	26	8,6%
40-50 min	26	8,6%	40-50 min	19	6,3%	40-50 min	15	5,5%
1 hour	48	15,8%	1 hour	40	13,2%	1 hour	28	9,2%
2 hours	16	5,3%	2 hours	10	3,3%	2 hours	6	2%
3 hours	4	1,3%	3 hours	3	1%	3 hours	2	0,7%
4 hours	3	1%	4 hours	1	0,3%	4 hours	1	0,3%
5 hours	0	0%	5 hours	0	0%	5 hours	0	0%

Table 2 *Time spent on physical activity by level* reflects the time spent on physical activity according to three predefined levels (intense, moderate, and walk). Thirty-five percent of respondents do not engage in intense or moderate physical activity. In addition to these, 23.1% and 29.7% barely practice between 10 and 30 minutes of intense and moderate physical activity, respectively. On the other hand, 13.2% indicate that they do not practice walking, while 42.6% reach a range between 10 and 30 minutes of walking.

Table 3
Physical activity levels: intense, moderate, and walk

Intense			Moderate			Walk		
Days	No.	%	Days	No.	%	Days	No.	%
0	114	37,6%	0	121	39,9%	0	45	14,9%
1	58	19,1%	1	78	25,7%	1	50	16,5%
2	35	11,6%	2	33	10,9%	2	49	16,2%
3	28	9,2%	3	27	8,9%	3	50	16,5%
4	23	7,6%	4	17	5,6%	4	25	8,3%
5	26	8,6%	5	15	5%	5	32	10,6%
6	16	5,3%	6	5	1,7%	6	16	5,3%
7	3	1%	7	7	2,3%	7	36	11,9%

According to *Table 3 Levels of physical activity: intense, moderate, and walk,* 37.6%, 39.9%, and 14.9% have not engaged in intense or moderate physical activity or walking, respectively, any of the last seven days. Only 19.1% and 25.7% have performed intense or moderate activity, respectively, one of the last seven days; while 16.5% have practiced walking within the same period.

Table 4
Sitting time

Time	**No.**	**%**
30 min	10	3,3%
1 hour	6	2%
2 hours	11	3,6%
3 hours	22	7,3%
4-6 hours	73	24,1%
7-8 hours	69	22,8%
9-10 hours	59	19,5%
+ 10 hours	53	17,5%

According to *Table 4 Sitting time*, the majority of participants surveyed have sat more than 4 hours during 1 day: 24%, between 4 and 6 hours; 22.8%, between 7 and 8 hours; 19.5%, between 9 and 10 hours; and 17.5% more than 10 hours.

In summary, it was found that the majority of respondents were women (63%), teachers (74.9%), over 41 years of age (52.8%), that few of them dedicated time to intense physical activity (35%), moderate (35.3%), or walking (13.2%), that they had not engaged in intense physical activity (37.6%), moderate (39.9%), or walking (14.9%) in the last seven days, and that they had not engaged in intense physical activity (37.6%), moderate (39.9%), or walking (14.9%); while the number of hours spent sitting increases exponentially from 4-6 hours (24.1%), 7-8 hours (22.8%), 9-10 hours (19.5%), more than 10 hours (17.5%). From the crossing of these variables, it could be pointed out that most of the respondents do not dedicate time to daily practice of intense, moderate or walking physical activity, while the number of hours spent sitting ranges from 4 to more than 10 hours for 83.9% of the surveyed population.

Discussion and conclusions

Discussion

In a broad sense, physical activity comprises the different activities in which the musculoskeletal system is involved, by means of which energy is consumed by the individual in a different way to that produced at rest (WHO, 2020). Therefore, it can vary in intensity (intense, moderate, light), frequency (daily, several times a week, once a week), and duration (in minutes and hours). Several authors have recognized the importance of physical activity as one of the main mechanisms for maintaining health and preventing numerous diseases: ischemic heart disease, arterial hypertension, cerebrovascular accidents (Varo, Martínez, & Martínez, 2003). In that direction, state programs for the promotion of physical activity should be interpreted as a strategy that favors the health of the population (Vidarte, Vélez, Sandoval & Alfonso, 2011). On the contrary, physical inactivity and sedentary lifestyles have been qualified as a direct cause of a large number of non-communicable diseases and deaths in the world (WHO, 2020) and as a real public health problem (Escalante, 2011). On the other hand, it should be emphasized that integral health should be understood not only as physical, emotional, and social stability but also includes elements of personal and social perception (Hellín, Moreno & Rodríguez, 2004), and that, in some contexts, physical activity has become an integral part of people's quality of life (Vigo, 2018).

Based on the WHO recommendations (2020), which state that adults aged 18 to 64 years should practice between 150 and 300 minutes of moderate aerobic physical activity, or between 75 and 150 minutes of intense aerobic physical activity per week. 58.1% and 65% of the participants in the study fall below the time range of intense and moderate physical activity, respectively. In addition, 85.1% and 91% do not reach the recommended 5 days of intense or moderate activity per week, and 83.9% of the respondents have remained seated for between 4 and more than 10 hours, completing the basic ingredients for the development of non-communicable diseases (cardiovascular, cancer, and diabetes), depression, anxiety, among others.

With the data available at the moment, it is not possible to determine the consequences that could be derived for the overall health of the participants due to the intensity, frequency, and duration of the physical activity performed during the study.

However, should further studies be able to confirm such a trend, several health problems could be presumed in the participants.

Conclusions

In view of the fact that most of the informants are directly related to the educational field (74.9% are teachers and 16.8% are administrative staff of a Higher Education Institution), it is of particular interest to contrast: 1) the number of hours they have been sitting (24.1%, between 4 and 6 hours; 22.8%, between 7 and 8 hours; 19.5%, between 9 and 10 hours; and 17.5% more than 10 hours), probably, dedicated to teaching, school, and/or administrative activities; 2) versus the percentage (37.6% and 39.9%) who have not practiced intense or moderate activity, respectively. With the intention of deepening the partial results obtained, further research should be carried out to determine the possible repercussions, in the medium and long term, on the integral health of the participants derived from the increasing physical inactivity and the prolonged amount of time spent in a sedentary position. In addition, it seems essential to carry out new studies that address the same problem in the light of a larger and more segmented sample and with an instrument that allows comparison of the physical activity variables and time spent sitting before and during the pandemic.

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