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The relationship between multidimensional social support and well-being in disability sport

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ABSTRACT

In this study, we investigated the relationships among perceived social support, perceived available support in sport, team cohesion, grit, sport engagement, and life satisfaction among disability sport athletes. Twenty-four athletes from Israel and Belgium, aged 22 to 65, 87.5% male ($n = 24$) and 12.5% female ($n = 3$), with physical disabilities participated. The results showed significant positive correlations between team cohesion and sport engagement ($r = 0.44$, $p < 0.05$) and life satisfaction ($r = 0.57$, $p < 0.01$). Team cohesion was also linked to perceived social support ($r = 0.55$, $p < 0.01$). Finally, grit and sport engagement ($r = 0.50$, $p < 0.01$) and perceived social support and sport engagement ($r = 0.50$, $p < 0.05$) were correlated. These findings underscore the importance of supportive social environments inside and outside of sport in potentially enhancing athlete well-being.

KEYWORDS

multidimensional social support; disability sport; sport psychology; athlete support system

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INTRODUCTION

Participating in sport can be stressful. Although athletes' with disabilities psychological skills are considered an important method to manage stress, social support is also very critical (Swanson et al., 2008; Udry et al., 1997). Social support is particularly important for athletes with disabilities (Atkinson & Martin, 2020; Martin & Mushett, 1996; Shapiro & Martin, 2010; 2014). Athletes with disabilities experience a lack of social support as they usually have few close friends and they have minimal contact with

teammates because they frequently have to train by themselves (Braithwaite et al., 1999; Martin, 2019; 2018; 2010). As a result, social support inside and outside of sport may be very important. Social support is also a crucial marker of well-being and correlates positively with various favorable personal, psychological, behavioral, social, interpersonal, and intrapersonal outcomes (Proctor et al., 2009). In brief, the purpose of this study is to address the lack of disability sport social support research by determining if various forms of sport and non-sport specific social support predict well-being markers in and outside of sport. It also extends Martin's line of work on social influence by examining forms of social support (e.g., team cohesion) that have been under-researched in disability sport (Falcão et al., 2015).

Our first purpose was to examine to what degree three types of social support predicted grit, sport engagement, and life satisfaction. Our second purpose was to provide important descriptive information on all of our variables, particularly the social support variables because social support has been under-researched in disability sport. In the following sections, we discuss the variables examined in the current study.

Our first type of perceived social support (PSS) is derived from friends, family, and significant others, and how these sources can provide support, information, and feedback. PSS does not distinguish between types (e.g., emotional versus informational) of social support. The social support resources provided by others can either have a positive or negative effect on an individual (Zimet et al., 1988). Perceived social support is defined as an individual's accessibility to the support that they receive from family, friends, and significant others and it is not sport-specific. This form of social support is thought to influence athletes' self-confidence (Freeman & Rees, 2010). Hence, by extension, we also believe it should be positively linked to our well-being measures.

The second type of social support is perceived available social support in sport and is therefore sport specific, unlike the PSS. It covers four different dimensions: emotional, esteem, informational, and tangible dimensions of support. Athletes rate their perceived level of support from four different sources: coach support, teammate support, family support, and friend support (Cutrona & Russell, 1990; Freeman et al., 2011). Emotional support is when an individual feels loved and cared for by others who are there for them. Esteem support is the reinforcement of one's self-esteem or sense of competence by others. Informational support is knowledge provided by others such as where an athlete can train and also refers to the influential support provided by others (Cutrona & Russell, 1990). Furthermore, this form of sport social support is also different from our first type of social support (i.e., PSS) as it measures four different types of social support from four different resources (Freeman et al., 2011).

Team cohesion is our third form of social support and is considered a very important small-group variable (Golembiewski, 1962; Lott & Lott, 1965). Team cohesion is what makes group members remain in a group they are part of (Festinger, 1950). The model has two major distinctions: Individuals versus groups, and task and social cohesion. Hence it is a model of four constructs: individual attraction to the group-social, individual attraction to the group-task social, group integration-social, and group integration-task (Brawley & Carron, 2002; Carron et al., 1985). This multidimensional measure is considered one of the most important group variables for sport teams (Brawley & Carron, 2002). Finally, the current measure is conceptually different from

our first two social support measures. Cohesion is how an athlete expresses their feelings about the sport team they are working with. The main idea of this measure is to assess how much social support exists within the group of athletes and unlike the first two forms, not from their environment or the people they are living with.

The diversity of our measures of social support provides a comprehensive view of social support that is sport-specific and non-sport-specific. As a result, our three measures allow us to have a better understanding of the type of support needed under different conditions and the ability to predict our three forms of well-being (Holt, 2006; Petrie & Falkstein, 2008). Athletes need distinctive forms of support to deal with both non-sport and sport-specific life challenges and demands (Rees & Hardy, 2000). Therefore, researchers indicate that social support measures should be aligned with the athletes and the situation in which they are assessed (Bianco & Eklund, 2001; Wills, 2000). In this study, we sought wanted to determine which type of social support would be best at predicting, three distinct forms of well-being; grit, sport engagement, and life satisfaction.

Next, we discuss our well-being measures. First, we assessed grit to investigate athletes' long-term goals and their trait-level perseverance and passion toward those goals. Grit keeps individuals motivated during long-term projects with effort and interest and it is related to the need for achievement. Individuals with stronger grit follow their goals no matter if they are getting positive feedback or not (Duckworth et al., 2007).

Grit is related to sport success, which means grittier athletes tend to perform better than less gritty athletes (Duckworth et al., 2011; Ford et al., 2012). Larkin et al. (2016), also indicated that grittier soccer players were more inclined to spend long periods of time engaging in sport-specific activities compared to their counterparts.

Our second well-being variable is sport engagement, which is defined as a persistent, positive, cognitive-affective experience in sport with four core dimensions. The dimensions are confidence, dedication, vigor, and enthusiasm. Confidence is defined as a sense of self-assurance in one's capability to perform at a high level. Dedication is defined as a strong motivation to put in the effort and allocate time toward accomplishing goals that an individual considers crucial. Vigor is characterized as a manifestation of physical, mental, and emotional energy and animation. Last, enthusiasm is defined as a feeling of excitement and high levels of enjoyment (Lonsdale et al., 2007). Hence, it is a broader measure of sport well-being compared to grit.

Researchers have also found that team cohesion is associated with lower burnout symptoms in athletes (Pacewicz et al., 2020). Additionally, the more engaged the athletes are in sports the less they experience burnout. Burnout is the conceptual opposite of sport engagement. Hence, the Pacewicz et al. (2020) results indirectly supports our hypothesis that team cohesion should be positively linked to sport engagement.

Our last dependent variable is life satisfaction, is non-sport-specific, which is defined as a cognitive judgmental process resulting in a global judgment of one's quality of life. These judgments are dependent on one's actual situation in comparison with what they believe as a standard and they compare their current situation with that standard. In brief, life has different aspects such as health, wealth, or marital bliss, and due to that, people assign different weights to each domain (Diener et al., 1985).

Perceived social support is positively related to life satisfaction. This means a higher level of perceived social support is associated with higher life satisfaction in comparison with lower social support (Achour & Nor, 2014; Duru, 2007; Heintzelman & Bacon, 2015; Mahanta & Aggarwal, 2013). Social support has also been correlated with physical health and being engaged in sports and physical activity (Uchino et al., 1996). In other words, social support has been recognized as an effective factor in people's perceptions of sport engagement (King et al., 2008).

In terms of hypotheses, our three diverse forms of social support were expected to be positively related to grit, sport engagement, and life satisfaction. However, given the exploratory nature of our study, we were unsure of what relationships among the various combinations of dependent and independent variables would be strongest. However, we expected a sport specific construct like team cohesion to be more strongly linked to a sport specific outcome such as sport engagement than a non-sport specific outcome such as life satisfaction.

In summary, social support is critical to athletes' well-being, particularly disabled athletes. In addition, little social support research in disability sport has been done and no research has examined three diverse forms of social support and how they are related to three forms of well-being. Hence our study addresses a research gap on an important topic in the psychology of disability sport.

METHOD

Participants and setting

Twenty-four (n = 24) national level wheelchair athletes from Israel (n = 16) and Belgium (n = 8) participated in this study. Athletes ranged in age from 22 to 65 years (M = 39.7, SD = 11.89). Participants reported physical disabilities and had been using a wheelchair for years ranging from 4 years to 38 years at the time of the data collection. The breakdown by gender was 87.5% male (n = 24) and 12.5% female (n = 3). Participants had physical disabilities such as amputation, paraplegia, diplegia, cerebral palsy, spina bifida, cauda equina syndrome, or brain injury.

MEASURES

Demographic scale

The demographic information provided by athletes included their age, gender, ethnicity, disability condition, years of wheelchair use, and team position.

Instruments

Each scale and subscale are described next:

Independent variables

Perceived social support

Perceived social support was measured with the Multidimensional Scale of Perceived Social Support (MSPSS) (Zimet et al., 1988). It has three subscales: friends, family, and significant others. The MSPSS has a total of 12 items with four items

for each subscale. Participants answered on a 7-point rating scale ranging from very strongly disagree (1) to very strongly agree (7). An example item for the family is "My family really tries to help me". An example item describing friends is "My friends really try to help me". And an example item for significant other is "There is a special person who is around when I am in need". The scores produced by this scale have demonstrated adequate internal and test-retest reliability as well as the validity (Zimet et al., 1988).

Perceived available support in sport

Perceived available support in sport was measured with the Perceived Available Support in Sport Questionnaire (PASS-Q). The PASS-Q is a 16-item, four-factor scale in which four questions represent each factor. An example item for emotional support is "Provide you with comfort and security". An example item for esteem support is "Reinforce the positives". An example item for Informational support is "Give you constructive criticism". An example item for tangible support is "Help with travel to training and matches". Participants rated the questions on a 5-point Likert scale and expressed their satisfaction (from 1 very dissatisfied – 5 very satisfied), difficulty (from 1 very difficult – 5 very easy), and importance (from 1 very unimportant – 5 very important). The structural validity and reliability of the scores of this measure are strong (Freeman et al., 2010).

Team cohesion

Social cohesion was measured with the Group Environment Questionnaire (GEQ). The GEQ consists of 18 questions and has four subscales. Individual attractions to the group social (ATGS) is "I enjoy being a part of the social activities of this team". An example item for individual attractions to the group-task social (ATGT) is "I like the amount of playing time I get". An example item for group integration social (GIS) is "Members of our team would rather get together as a team than hang out on their own". An example item for the group-integration task (GIT) is "Our team works together in trying to reach its goals for performance". Participants rated the question on a 7-point scale (Strongly disagree = 1 to Strongly agree = 7) (Eys et al., 2007). The validity and reliability of the scores produced by this measure are also strong (Carron et al., 1998).

Dependent variables

Grit

Grit was measured with the Grit-S scale which consists of 12-items with two subscales: Consistency of interest and perseverance of effort. A sample question from the consistency of interest is "I often set a goal but later choose to pursue a different one". An example item for the perseverance of effort scale is "I have achieved a goal that took years of work". Participants rated the questions on a 5-point Likert-type scale ranging Using a 5-point Likert-type scale ranging from 1 (Not at all like me) to 5 (Very much like me). Six items are reverse scored (questions 1 to 6). The validity and reliability of the scores measured by this scale are strong (Duckworth et al., 2007).

Sport engagement

Sport engagement was measured by the 16-item Athlete Engagement Questionnaire (Lonsdale et al., 2007). The scale consists of four subscales: confidence, dedication, vigor, and enthusiasm. A sample question for confidence is "I believe I am capable of accomplishing my goals in sport". An example item for dedication is "I am dedicated to achieving my goals in sport". An example item for vigor is "I feel energetic when I participate in my sport". An example item for enthusiasm is "I feel excited about my sport". Athletes responded using a 5-point Likert scale (1 = almost never, 5 = almost always). The validity and reliability of scores produced by this scale are strong (Martins et al., 2014).

Life satisfaction

We measured life satisfaction with a 5-item scale designed to measure participant's cognitive judgments of one's life satisfaction. A sample item for this scale is "The conditions of my life are excellent". Participants indicate how much they agree or disagree with each of the 5 items using a 7-point scale that ranges from 7 strongly agree to 1 strongly disagree (Diener et al., 1985). The validity and reliability of scores produced by this measure are adequate (Zanon et al., 2014).

Procedures

We conducted the study after getting permission from the University's Internal Review Board and the athletes. Athletes filled out the questionnaires individually during practice.

Data analysis

IBM SPSS (Version 29.00) was used for all analyses. Data were initially screened for missing data, outliers, and normal distribution characteristics. Internal consistency estimates, descriptive statistics, and simple correlations for all variables were then calculated.

RESULTS

Reliability, validity, and descriptive statistics

Participants in the study demonstrated moderately high scores across all three social support measures (See Table 1), with scores consistently ranging from 1 to 1.5 units above the scale midpoint. These findings contradict our initial claims that athletes with disabilities may experience a lack of social support. Moderate scores were also reported for grit, sport engagement, and life satisfaction. Overall, the participant group was relatively homogeneous, as indicated by small standard deviations for most constructs, particularly for perceived social support and life satisfaction.

Most variables were normally distributed, with skewness ranging from –2.11 to 0.08 and kurtosis from –0.97 to 2.58 (Cramer, 1998), except for the variable sport engagement. The internal reliability of the six scales was acceptable, with Cronbach's alphas ranging from 0.76 to 0.95 (Cronbach, 1951) as shown in Table 1. The following sections discuss five significant correlations.

Table 1 Pearson product-moment correlations and descriptive statistics for all variables

	1	2	3	4	5	6
1. Perceived social support	_					
2. Perceived available support in sport	0.393	_				
3. Social cohesion	0.549**	0.093	_			
4. Grit	0.348	−0.054	0.396	_		
5. Sport engagement	0.504*	−0.141	0.440*	0.504*	_	
6. Life satisfaction	0.396	−0.036	0.572**	0.117	0.379	_
M	5.32	3.66	4.47	3.13	4.18	4.78
SD	1.43	0.69	0.96	0.47	0.77	1.48
Skewness	−1.17	0.08	−1.46	−0.16	−2.11	−0.79
Kurtosis	1.10	−0.97	2.58	−0.95	6.64	0.47
Alphas	0.95	0.89	0.90	0.76	0.96	0.89

Note: $N = 24$, M = mean, SD = standard deviation.

*$p < 0.05$, **$p < 0.01$

Correlations

Team cohesion and sport engagement: Results show that higher team cohesion is significantly associated with higher sport engagement (r = 0.440, $p < 0.05$). This indicates that athletes who experience stronger team cohesion are more engaged in sport compared to those with lower team cohesion.

Team cohesion and life satisfaction: Higher team cohesion is significantly associated with higher life satisfaction (r = 0.572, $p < 0.01$). Athletes with stronger team cohesion reported higher levels of life satisfaction than those with less cohesion.

Perceived social support and sport engagement: Results indicate that greater perceived social support is significantly associated with higher sport engagement (r = 0.504, $p < 0.01$). Athletes who receive more social support from their families, friends, and significant others tend to be more engaged in sports compared to those receiving less support.

Team cohesion and multidimensional perceived social support: A significant positive relationship was found between team cohesion and multidimensional perceived social support (r = 0.549, $p < 0.01$). This suggests that higher levels of team cohesion are associated with greater perceived social support, as both measure different aspects of social influence.

Sport engagement and grit: Results show that higher grit is significantly associated with higher sport engagement (r = 0.504, $p < 0.01$). Athletes who demonstrate greater grit are more likely to be engaged in sports compared to those with lower grit.

DISCUSSION

The primary purpose of our study was to determine the relationships among perceived social support, perceived available support in sport, and social cohesion with grit, sport engagement, and life satisfaction. We found some support for our hypotheses.

First, our findings support the idea that athletes with disabilities who were high in social cohesion strong engagement in their sport-related activities. An individual high in social cohesion enjoys doing activities with other people on a team like playing sports and socializing. Athletes on teams high in cohesion also like participating in sports and having fun with teammates. Therefore, it's reasonable that people who enjoy team social activities report high sport engagement. Researchers have supported this relationship as Bruner et al. (2014) found team sport members with stronger relationships with team members had more team social cohesion. Sport events are competitive situations that can be stressful and challenging and this can be even worse for athletes with disabilities who face more barriers (e.g., inaccessible sport facilities) to practice and competition compared to able-bodied athletes. Team cohesion can significantly and positively predict athlete engagement with a more important role played by group-task social ATG-T (Gu et al., 2022).

Second, athletes with high team cohesion also indicated high life satisfaction. A person high in social cohesion enjoys being part of team social activities with others like going out to eat and they enjoy other people's happiness. Hence, it makes sense that if people enjoy social elements with others, they like their life better and are more satisfied with their life than those who don't enjoy these things. Martin et al. (2015), indicated that athletes with higher resilience were more engaged in sport and, they also reported higher levels of life satisfaction. Team cohesion from groups and teammates can result it more gratitude in athletes that can lead to enhanced life satisfaction (Chen et al., 2015).

Third, we found that athletes who received higher perceived social support reported greater sport engagement compared to athletes who received less social support. This finding is not unexpected as it is plausible that athletes who received social support from their families, friends, and significant others will be more involved in sport compared to athletes who receive less social support. Athletes who receive support from their teammates or coaches are likely to have enhanced sport engagement and well-being (Mellano & Pacewicz, 2023). Social support is a vital external resource that can significantly increase athletes' sport engagement. Implementing a high level of social support for athletes is one of the most important ways to promote their sport engagement. Coaches who have substantial expertise and extensive experience in training and competition can effectively enhance athletes' motivation to participate in training, encourage them to use maximum effort, and improve their level of engagement (Curran et al., 2015). Researchers have indicated that parents or guardians play an equally significant role as coaches in supporting, guiding, and supervising adolescent athletes (Martin & Mushett, 1996; Smoll et al., 2011). In brief, it is quite plausible that having a source of support with whom athletes can share their problems with can lead to greater sport engagement.

Fourth, results of our study suggest that athletes who were higher in team cohesion were also more likely to have stronger perceived social support compared to athletes

who had lower team cohesion. These findings are rationale because both these variables are built on trust. Individuals are more likely to trust people when they perceive strong support from friends, family, and significant others. Similarly, in socially cohesive teams, members trust each other, cooperate, and provide mutual support, thereby reinforcing feelings of support and connectedness. Furthermore, perceived social support improves individuals' emotional well-being by reducing stress, strengthening coping abilities, and fostering psychological resilience. Feeling supported leads to fewer negative emotions and higher life satisfaction. Likewise, in socially cohesive groups, members benefit from emotional support provided by peers, which enhances their psychological well-being and satisfaction within the group.

Fifth, our findings support the idea that grittier athletes showed higher sport engagement compared to less gritty athletes. Based on research studies athletes with greater grit outperform athletes with lesser grit on sport-specific perceptual-cognitive tests and have higher sport engagement (Larkin et al., 2016). This positive correlation is plausible as engagement in sports and having grit both require a strong commitment to goals. Athletic engagement and grit also share underlying mechanisms related to goal pursuit, self-belief, intrinsic drive, and positive psychological emotions (Tedesqui & Young, 2019).

We should also note that some of our variables were unrelated to each other. Grit and life satisfaction were unrelated to perceived available support in sport. Hence, social support in sport doesn't appear to help promote grit or life satisfaction. It is reasonable and not unexpected that social support specific to sport is not likely to influence non sport specific variables like grit and life satisfaction that are impacted by many other factors such as family life, careers, disability issues, etc.

In summary, in this study we examined the relationships among sport and non-sport specific predictors: social support in and outside of sport and team cohesion of grit, sport engagement and athlete satisfaction. We found that athletes who felt supported by family, friends, and coaches demonstrated higher engagement in sport than athletes reporting less support in these areas. Additionally, athletes high in team cohesion reported stronger perceived social support compared to athletes reporting lower team cohesion. Strong team cohesion was also linked to higher life satisfaction. These findings emphasize the importance of encouraging supportive social environments to promote athlete well-being.

While this study primarily examines the relationship between social support and the well-being of athletes with disabilities, it does not consider other significant factors that may impact their well-being, such as economic conditions, access to healthcare, or psychological factors unrelated to social support. Including these aspects could offer a more comprehensive understanding of the influences on these athletes' well-being and should be acknowledged in future research. Additionally, our study measured social support and well-being at a single point in time, which does not account for potential changes in these variables over time. Since data collection occurred during sports training sessions, participants' responses may have been influenced by their immediate psychological or physical state, potentially leading to biased answers regarding social support or well-being. Future research could benefit from employing alternative data collection methods, such as gathering data in different contexts or over multiple time points. Integrating qualitative approaches, like in-depth interviews

or focus groups, could also provide a richer, more nuanced understanding of these relationships.

CONCLUSION

In conclusion, our study highlights the significant role that social factors play in the well-being and engagement of athletes with disabilities. Our findings suggest that strong team cohesion and perceived social support are key predictors of higher sport engagement and life satisfaction. Specifically, athletes who experience greater cohesion within their teams are more likely to be engaged in their sport and report higher life satisfaction. Additionally, athletes who feel supported by their families, friends, and coaches tend to be more involved in their sport.

These findings underscore the importance of fostering supportive and cohesive environments within sports teams, particularly for athletes with disabilities who may face additional challenges. Overall, our research suggests that enhancing social support and team cohesion can lead to meaningful improvements in athlete engagement and overall well-being. By prioritizing these social factors, coaches, families, and sports organizations can contribute to the success and satisfaction of athletes with disabilities.

LIMITATION

First, the small sample size means our findings are likely sample-specific and may not replicate. Second, the correlation nature of our study precludes establishing cause and effect conclusions. However, our results are consistent with theory, logic, and prior able-bodied research, that if athletes have social support in their lives they are likely to have psychological benefits (e.g., life satisfaction). Hence, the significant relationships are suggestive of different social variables having positive effects on psychological variables. It is also important to point out potential bi-directional and reciprocal pathways. For instance, athletes high in sport engagement may attract greater social support from significant others compared to athletes who appear disengaged towards their sport.

REFERENCES

Achour, M., & Nor, M. R. M. (2014). The effects of social support and resilience on life satisfaction of secondary school students. *Journal of Academic and Applied Studies*, *4*(1), 12–20.

Atkinson, F., & Martin, J. (2020). Gritty, hardy, resilient, and socially supported: A replication study. *Disability and Health Journal*, *13*(1), 100839.

Bianco, T., & Eklund, R. C. (2001). Conceptual considerations for social support research in sport and exercise settings: The case of sport injury. *Journal of Sport and Exercise Psychology*, *23*(2), 85–107.

Braithwaite, D. O., Waldron, V. R., & Finn, J. (1999). Communication of social support in computer-mediated groups for people with disabilities. *Health Communication*, *11*(2), 123–151.

Brawley, L. R., & Carron, A. V. (2002). *The group environment questionnaire: Test manual*. Fitness Information Technology.

Bruner, M. W., Boardley, I. D., & Côté, J. (2014). Social identity and prosocial and antisocial behavior in youth sport. *Psychology of Sport and Exercise*, *15*(1), 56–64. https://doi.org/10.1016/j.psychsport.2013.09.003.

Carron, A. V., Widmeyer, W. N., & Brawley, L. R. (1985). The development of an instrument to assess cohesion in sport teams: The Group Environment Questionnaire. *Journal of Sport and Exercise Psychology*, *7*(3), 244–266. https://doi.org/10.1123/jsp.7.3.244.

Carron, A. V., Brawley, L. R., & Widmeyer, W. N. (1998). The measurement of cohesiveness in sport groups. In: J. L. Duda (Ed.), *Advances in Sport and Exercise Psychology Measurement* (pp. 213–226). Morgantown, WV: Fitness Information Technology.

Chen, L. H., Kee, Y. H., & Chen, M. Y. (2015). Why grateful adolescent athletes are more satisfied with their life: The mediating role of perceived team cohesion. *Social Indicators Research*, *124*, 463–476.

Cramer, D. (1998). *Fundamental statistics for social research: Step-by-step calculations and computer techniques using SPSS for Windows*. Mahwah, NJ: Psychology Press.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297–334.

Curran, T., Hill, A. P., Hall, H. K., & Jowett, G. E. (2015). Relationships between the coach-created motivational climate and athlete engagement in youth sport. *Journal of Sport and Exercise Psychology*, *37*(2), 193–198.

Cutrona, C. E., & Russell, D. W. (1990). Type of social support and specific stress: Toward a theory of optimal matching. In: B. R. Sarason, I. G. Sarason, & G. R. Pierce (Eds.), *Social Support: An interactional view* (pp. 319–366). New York, NY: Wiley.

Diener, E. D., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. *Journal of Personality Assessment*, *49*(1), 71–75.

Duckworth, A. L., Kirby, T. A., Tsukayama, E., Berstein, H., & Ericsson, K. A. (2011). Deliberate practice spells success why grittier competitors triumph at the national spelling bee. *Social Psychological and Personality Science*, *2*(2), 174–181.

Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and Passion for Long-Term Goals. *Journal of Personality and Social Psychology*, *92*(6), 1087–1101. https://doi.org/10.1037/0022-3514.92.6.1087.

Duru, E. (2007). Re-examination of the psychometric characteristics of the multidimensional scale of perceived social support among Turkish university students. Social Behavior and Personality: *An International Journal*, *35*(4), 443–452.

Eys, M. A., Carron, A. V., Bray, S. R., & Brawley, L. R. (2007). Item wording and internal consistency of a measure of cohesion: The Group Environment Questionnaire. *Journal of Sport and Exercise Psychology*, *29*(3), 395–402.

Falcão, W. R., Bloom, G. A., & Loughead, T. M. (2015). Coaches' perceptions of team cohesion in Paralympic sports. *Adapted Physical Activity Quarterly*, *32*(3), 206–222.

Festinger, L., Schachter, S., & Back, K. (1950). *Social pressures in informal groups: A study of human factors in housing*. Stanford, CA: Stanford University Press.

Ford, P., Carling, C., Garces, M., Marques, M., Miguel, C., Farrant, A., Stenling, A., Moreno, J., Le Gall, F., Holmström, S., Salmela, J. H., & Williams, A. M. (2012). The developmental activities of elite soccer players aged under-16 years from Brazil, England, France, Ghana, Mexico, Portugal and Sweden. *Journal of Sport Sciences*, *30*(15), 1653–1663.

Freeman, P., & Rees, T. (2010). Perceived social support from team-mates: Direct and stress-buffering effects on self-confidence. *European Journal of Sport Science*, *10*(1), 59–67. https://doi.org/10.1080/17461390903049998.

Freeman, P., Coffee, P., & Rees, T. (2011). The PASS-Q: The perceived available support in sport questionnaire. *Journal of Sport and Exercise Psychology*, *33*(1), 54–74.

Golembiewski, R. T. (1962). The Development of a Scale for the Measurement of Group Cohesiveness. *Administrative Science Quarterly*, *7*(1), 71–88.

Gu, S., & Xue, L. (2022). Relationships among sports group cohesion, psychological collectivism, mental toughness and athlete engagement in Chinese team sports athletes. *International Journal of Environmental Research and Public Health*, *19*(9), 4987.

Heintzelman, S. J., & Bacon, P. L. (2015). Relational self-construal moderates the effect of social support on life satisfaction. *Personality and Individual Differences*, *73*, 72–77.
Holt, N. L., & Hoar, S. D. (2006). The multidimensional construct of social support. In: S. Hanton & S. Mellalieu (Eds.), *Literature Reviews in Sport Psychology* (pp. 199–225). Hauppauge, NY: NovaScience Publishers. https://doi.org/10.1080/10413209808406376.
King, K. A., Tergerson, J. L., & Wilson, B. R. (2008). Effect of social support on adolescents' perceptions of and engagement in physical activity. *Journal of Physical Activity and Health*, *5*(3), 374–384.
Larkin, P., O'Connor, D., & Williams, A. M. (2016). Does grit influence sport-specific engagement and perceptual-cognitive expertise in elite youth soccer? *Journal of Applied Sport Psychology*, *28*(2), 129–138.
Larkin, P., O'Connor, D., & Williams, A. M. (2016). Does grit influence sport-specific engagement and perceptual-cognitive expertise in elite youth soccer? *Journal of Applied Sport Psychology*, *28*(2), 129–138.
Lonsdale, C., Hodge, K., & Jackson, S. A. (2007). Athlete engagement: II. Developmental and initial validation of the Athlete Engagement Questionnaire. *International Journal of Sport Psychology*, *38*(4), 383–397.
Lonsdale, C., Hodge, K., & Jackson, S. A. (2007). Athlete engagement: II. Development and initial validation of the Athlete Engagement Questionnaire. *International Journal of Sport Psychology*, *38*, 471–492.
Lott, A. J., & Lott, B. E. (1965). Group cohesiveness as interpersonal attraction: A review of relationships with antecedent and consequent variables. *Psychological Bulletin*, *64*(4), 259–309.
Mahanta, D., & Aggarwal, M. (2013). Effect of Perceived Social Support on Life Satisfaction of University Students. *European Academic Research*, *1*(6), 1083–1094.
Martin, J. J. (2019). Disability, physical activity, and psychological well-being. In: T. Horn & A. Smith (Eds.), *Advances in Sport and Exercise Psychology* (pp. 375–386).
Martin, J. J. (2018). *Handbook of Disability Sport and Exercise Psychology*. Oxford University Press.
Martin, J. (2010). The psychosocial dynamics of youth disability sport. *Sport Science Review*, *19*(5–6), 49–61.
Martin, J. J., Byrd, B., Watts, M. L., & Dent, M. (2015). Gritty, hardy, and resilient: Predictors of sport engagement and life satisfaction in wheelchair basketball players. *Journal of Clinical Sport Psychology*, *9*(4), 345–359. https://doi.org/10.1123/jcsp.2015-0015.
Martin, J., Dadova, K., Jiskrova, M., & Snapp, E. (2020). Sport engagement and life satisfaction in Czech parasport athletes. *International Journal of Sport Psychology*, *53*, 36–50.
Martin, J. J., & Mushett, C. A. (1996). Social support mechanisms among athletes with disabilities. *Adapted Physical Activity Quarterly*, *13*(1), 74–83.
Martins, P., Rosado, A., Ferreira, V., & Biscaia, R. (2014). Examining the validity of the Athlete Engagement Questionnaire (AEQ) in a Portuguese sport setting. *Motriz: Revista de Educação Física*, *20*(1), 1–7.
Mellano, K. T., & Pacewicz, C. (2023). The influence of social support provider on adolescent athlete burnout and engagement. *Journal of Clinical Sport Psychology*, *17*(4), 429–448.
Pacewicz, C. E., Smith, A. L., & Raedeke, T. D. (2020). Group cohesion and relatedness as predictors of self-determined motivation and burnout in adolescent female athletes. *Psychology of Sport and Exercise*, *50*, 101709. https://doi.org/10.1016/j.psychsport.2020.101709.
Proctor, C. L., Linley, P. A., & Maltby, J. (2009). Youth life satisfaction: A review of the literature. *Journal of Happiness Studies*, *10*, 583–630.
Petrie, T. A., & Falkstein, D. L. (1998). Methodological, measurement, and statistical issues in research on sport injury prediction. *Journal of Applied Sport Psychology*, *10*(1), 26–45.

Rees, T., & Hardy, L. (2000). An investigation of the social support experiences of high-level sports performers. *The Sport Psychologist*, *14*(4), 327–347.

Shapiro, D. R., & Martin, J. J. (2014). The relationships among sport self-perceptions and social well-being in athletes with physical disabilities. *Disability and Health Journal*, *7*(1), 42–48.

Shapiro, D. R., & Martin, J. J. (2010). Athletic identity, affect, and peer relations in youth athletes with physical disabilities. *Disability and Health Journal*, *3*(2), 79–85.

Smoll, F. L., Cumming, S. P., & Smith, R. E. (2011). Enhancing coach-parent relationships in youth sports: Increasing harmony and minimizing hassle. *International Journal of Sports Science & Coaching*, *6*(1), 13–26.

Swanson, S. R., Colwell, T., & Zhao, Y. (2008). Motives for participation and importance of social support for athletes with physical disabilities. *Journal of Clinical Sport Psychology*, *2*(4), 317–336.

Tedesqui, R. A., & Young, B. W. (2019). Relationships between athletes' self-reported grit levels and coach-reported practice engagement over one sport season. *Journal of Sport Behavior*, *42*(4), 509–523.

Uchino, B. N., Cacioppo, J. T., & Kiecolt-Glaser, J. K. (1996). The relationship between social support and physiological processes: a review with emphasis on underlying mechanisms and implications for health. *Psychological Bulletin*, *119*(3), 488–531.

Udry, E., Gould, D., Bridges, D., & Beck, L. (1997). Down but not out: Athlete responses to season-ending injuries. *Journal of Sport and Exercise Psychology*, *19*(3), 229–248.

Williams, A. M., Ward, P., Bell-Walker, J., & Ford, P. R. (2011). Perceptual-cognitive expertise, practice history profiles and recall performance in soccer. *British Journal of Psychology*, *103*(3), 393–411.

Wills, T. A. & Shinar, O. (2000). Measuring perceived and received social support. In: S. Cohen, L.G. Underwood, & I. Gotlieb (Eds.), *Social Support Measurement and Interventions* (pp. 86–135). New York: Oxford University Press.

Zanon, C., Bardagi, M. P., Layous, K., & Hutz, C. S. (2014). Validation of the Satisfaction with Life Scale to Brazilians: Evidences of measurement noninvariance across Brazil and US. *Social Indicators Research*, *119*, 443–453. https://doi.org/10.1007/s11205-013-0478-5.

Zimet, G. D., Dahlem, N. W., Zimet, S. G., & Farley, G. K. (1988). The multidimensional scale of perceived social support. *Journal of Personality Assessment*, *52*(1), 30–41.

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The impact of the covid-19 pandemic on sports – reporting in the daily newspapers of the Czech Republic

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ABSTRACT

The Czech quality (non-tabloid) nationwide daily newspapers never published fewer sports pages during the two first decades of twenty-first century than they did during the COVID-19 pandemic. A reduction in the number of pages devoted to sports and other topics was a logical reaction to the paralysis of professional sports and many other domains of human life. But a comparison of data from the first wave of the pandemic, from March to May of 2020 with the same period in the following years proves that the trend to downsize sports sections continued in many cases. This study applied quantitative content analysis to the Monday editions of the Czech daily newspapers *Hospodářské noviny*, *Lidové noviny*, *Mladá fronta Dnes*, and *Právo*. It confirmed that the position of sport in the daily newspapers has weakened in the long term, and the pandemic accelerated the tendency, especially in the case of more specialised daily newspapers.

KEYWORDS

sports journalism; print media; lockdown; suspension of sports events; reduction of sports content

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INTRODUCTION

The year 2020 could have been like previous even-numbered years, full of the most prestigious sporting events. Tokyo was preparing to host the Olympic Games and twelve stadiums in different countries had been chosen for a special edition of football's European Championship celebrating that tournament's sixtieth anniversary. In the Czech Republic, ice hockey fans were anticipating the world championships to be held in Switzerland. Due to the pandemic, the Olympics and the Euro Cup were postponed until 2021, and the hockey championship was cancelled altogether. The organisers of

other sporting events had to react as well: the most famous tennis tournament, Wimbledon, was not held at all, and the Roland Garros Grand Slam and the prestigious Tour de France cycling race were moved into autumn instead of spring or summer as usual.

The COVID-19 pandemic affected all domains of human life, and sport was no exception. If the seemingly never-ending flow of sports events had to stop for a couple of months, so did the sports content produced by the media. The consequences of the pandemic for sports journalism are the main subject of this research. This paper focuses on the sports sections of selected daily newspapers in the Czech Republic during the first weeks of the pandemic, in the spring of 2020 when all the domestic sports competitions were postponed or, more often, cancelled. The main foreign events of the European football leagues, including international matches, the UEFA Champions League, and the Europa League re-started after an enforced pause of two months.

This research focused on newspapers because from a historical perspective, they represent the traditional media, and also because the print media faced special problems in the crisis. Although public demand for information grew stronger, the newspapers contended with a large decrease in sales because people were forced to stay home. This resulted in a 20 percent reduction in newspaper sales in April 2020 (Mediaguru, 2020a). Losses in the print media's advertising revenues were even more critical – down 34 percent in the same month of 2020 (Mediaguru, 2020b).

This article is based on quantitative analysis. It describes how in a crisis the print media rearranged the standard column inches devoted to sports. It deals exclusively with the newspapers' Monday editions, which in the Czech Republic contain the most robust sports section of the week. The findings compare the weeks of spring 2020 with the corresponding period of the preceding year, 2019, and the following year, 2021. The results are also compared to long-term trends discovered by previous research that monitored the sports pages of the newspapers from the beginning of the twenty-first century.

LITERATURE REVIEW

The program for some sporting events is published a few years in advance, including the organizing country, the host cities, the required stadiums, and a detailed plan for all games and races, often with the cooperation of broadcasters. Some prestigious events have traditionally set their dates decades in advance. In that sense, sports journalism differs from other news reporting and profits from knowing a fixed program in advance (Andrews, 2017). As journalism and sport co-evolved, sports media gained popularity and attracted the attention of a wide audience. The importance and power of sports in society greatly increased during the second half of the twentieth century thanks to the broad reach of the mass media. McChesney described this relationship as "*symbiotic*" (McChesney, 1989, p. 67).

Suddenly and unexpectedly in March 2020, there were almost no football matches or other sporting events. The cancellation of matches or playing them without any spectators (so-called "*ghost games*") threw sports organizations into financial trouble. Horky (2020, p. 101) explains: "*Professional sport is essentially a public performance – for media and broadcasting or for real spectators*". Suddenly, there were no live broadcasts on TV or radio stations, no live reports on Internet websites or mobile applications, and no commentaries or expert analyses in the newspapers. The newspapers

had to react and find substitutes for the standard sports content that was missing as a consequence of government lockdowns.

Substitutes for regular sports content

According to previous studies of various types of media (newspapers, websites, and TV stations) from different countries (including the United States and Germany), it is possible to identify some subjects and themes that that media chose as substitutes for sports reporting. They replaced the missing content with 1) news about COVID-19 and its consequences (Sadri et al., 2022); 2) timeless stories, mainly from sports history (Schallorn & Kunert, 2020); and 3) new content covering themes not hitherto discussed in the media (Goldman & Hedlund, 2020). The space devoted to sports could be also reduced. Sports reporters helped out in other departments of their media, covering other topics (Gentile et al., 2022).

Instead of traditional sports news, much information was reported concerning COVID-19 and the then-actual situation in sport, including restrictions and the possible consequences of the lockdowns for future sports events and training. Sadri et al. (2022) focused mainly on different framing of sports content in the United States media. They identified the most-used frames: health, economics, quality of life, fairness, and morality – which resulted in broader reporting than the usual sports reporting focused on the outcomes of matches.

Some TV stations substituted archived recordings of content for actual live broadcasts. Schallhorn & Kunert (2020) state that some German TV channels chose to re-broadcast memorable, dramatic games from history on the anniversary of the dates they took place before the pandemic. They called this "*turning the old into new*" (Schallhorn & Kunert, 2020, p. 516). Hull and Romney (2020) confirm the same trend but add that local sports broadcasters do not have a very large archive, which limits their options. Fans and supporters appreciated this re-run of history, for example, of the days in 1974 and 2014 when Germany won the football World Cup (Schallhorn & Kunert, 2020, p. 517). The re-broadcast of the World Cup final against Argentina in 2014 was followed by an "*unbelievable 1.67 million viewers in Germany*" (Horky, 2020, p. 100). On the other hand, rebroadcasting these games provoked criticism because the games lacked suspense, could simply be boring, and begged the question: "*Is that what we want from sports?*" (Schallhorn & Kunert, 2020, p. 517)

When traditional sports events were cancelled, new ones like e-sports could take the spotlight. Johnson & Woodcock (2021) remind us that the popularity of e-sports was growing even before the pandemic, but the new circumstances and more prominent media coverage boosted their popularity. Grix et al. (2020) note the significant growth of e-sports and expect immense attention on them in the future on the part of the International Olympic Committee. Horky agrees: "*The transformation of real sports into their digital versions is getting significant attention*" (Horky, 2020, p. 101).

Print newspapers

The reaction of print newspapers is relevant for the future of this traditional media. During the two first decades of the twenty-first century, the future of the daily press became the subject of controversy, as it did with the advent of radio and television in the twentieth. But this time, in competition with the so-called new media, the debate

was more intense than ever before. Despite the problems faced by the print media in terms of decreasing circulations and lower revenues resulting in the Czech Republic in the closure of *Lidové noviny* in August 2024 (Mediaguru, 2024), newspapers have not perished (Edge, 2019; O'Sullivan et al., 2017), at least for the moment. Nevertheless, the fate of their sports sections is unclear.

On the one hand, sports reporting is an attractive and desired kind of journalism, without which the media cannot attract a wide audience (Andrews, 2017; Toney, 2014). During previous decades, sports reporting was taking up more and more space in the newspapers (Biscomb & Matheson, 2017). In the Czech context, one can cite the example of *Lidové noviny* (Děkanovský, 2008). This traditional Czech newspaper reduced its coverage of sport in the late twentieth century but renewed its sports section later so as not to lose readers. Still, the situation not only at *Lidové noviny* has changed significantly with the advent of the "*new media*", which includes online news, the official websites of sports clubs, social networks, etc. The natural advantages and benefits of the internet make it "*the best medium for sports fans*" (Real, 2006, p. 183). The impact of the new competitor on the media scene was so great that this period is often called the "*digital revolution*" (Bradshaw & Minogue, 2019, p. 6).

The "*revolution*" deeply impacted sports sections in daily newspapers. Some forms of sports journalism simply could not compete with the internet. Match scores, statistics, pure descriptions of games, transfers and rumours are now found more easily and accessed more quickly in the stream of online information (Billings, Butterworth & Turman, 2018) thanks to journalism-as-process model (Moritz, 2015). The impact of social media on sports communication is also crucial (Nölleke, Grimmer & Horky, 2016). Therefore, some daily newspapers have reduced the number of pages they publish containing such information about sports, replacing it with sports commentary and analysis, some have even eliminated the whole sports section (Billings, Butterworth & Turman, 2018). The future of that traditional section of newspapers is uncertain (Hodgson, 2020), while online journalism become more attractive and perspective type of media sports production (Kian & Zimmerman, 2012).

Evidence of this trend appeared in the Czech media between 2001 and 2015, for example, in the nationwide quality newspapers *Hospodářské noviny*, *Lidové noviny*, and *Mladá fronta Dnes*, and to some extent in *Právo* (Trunečka, 2021). The number of pages those newspapers devoted to sport has decreased gradually since the economic crisis of 2008. Content has changed from straight sports news reporting into more sophisticated forms of sports journalism. This study analyses the immediate reaction of newspapers during the first wave of the COVID-19 pandemic in 2020, but also examines the following years 2021 and 2023 to discover potential long-term consequences of the pandemic.

The beginning of the pandemic in the Czech Republic

It was precisely the first day of March 2020 when the Czech Republic announced its first three cases of people who tested positive for the novel coronavirus (ČTK, 2020a). The very next day, the Czech National Security Council decided that the Biathlon World Cup would be held without an audience in Nové Město na Moravě because of the risks linked to the expected presence of tens of thousands of visitors, many of them from abroad (ČTK, 2020b). Other main events, including the domestic football and ice hockey leagues, continued without any restrictions. The most prestigious football

match, Slavia vs. Sparta, was played on 8 March with almost twenty thousand supporters in the stands (ČTK, 2020c).

The following week was crucial. First, on Tuesday, the government approved an attendance limit of one hundred people for any sporting event. The decision still allowed sports on the professional level, but without the presence of any fans (ČTK, 2020d). Just two days later, the government forbade all sports activities involving more than thirty people and restricted access to sports venues. Professional sport in the Czech Republic effectively ceased (ČTK, 2020e). As a consequence, the football association postponed all its matches. For the first time since 1945, the ice hockey league terminated its season prematurely without determining a new champion (ČTK, 2020f). Similar postponements and cancellations were announced in other countries.

The weekend of 14–15 March was the first one without public sports competitions, and this state of affairs remained the same until the second half of May. The Czech football league re-started on 23 May (ČTK, 2020g), albeit with hygienic restrictions and without the presence of supporters. This was one week later than the German football league, which was the first in Europe to resume matches (ČTK, 2020h). The football was the only one from among the other major sports in the Czech Republic to try to complete its season. It was almost completely successful, except for a few last matches in the relegation group. Many sports seasons terminated without a new champion, or winners were decided according to pre-lockdown results (Table 1).

Table 1 The decisions in some long-term team competitions in the Czech Republic

Sport	Men/Women	Date	Decision	Champion
Football	Men	12th March	Postponed	Slavia Prague
Football	Women	4th April	Terminated	Slavia Prague
Ice-hockey	Men	12th March	Terminated	–
Ice-hockey	Women	12th March	Terminated	–
Basketball	Men	18th March	Terminated	Nymburk
Basketball	Women	13th March	Terminated	USK Prague
Handball	Men	5th April	Terminated	–
Handball	Women	31st March	Terminated	–
Volleyball	Men	16th March	Terminated	–
Volleyball	Women	16th March	Terminated	–
Floorball	Men	13th March	Terminated	–
Floorball	Women	13th March	Terminated	–

Sources of data: News agency ČTK and official websites of selected sports associations

RESEARCH AIM

This research in the area of sports communication studies deals with daily newspapers as representatives of the traditional sports media. It describes the transforma-

tion and evolution of their sports sections from the beginning of the twenty-first century (between 2001 and 2015) (Trunečka, 2017; Trunečka, 2021) and adds information for subsequent years until 2023. This period includes the COVID-19 global pandemic.

METHODOLOGY

To begin the analysis of how the sports sections of daily newspapers reacted to the suspension of sporting events, three research questions were specified. They focus on the situation during the COVID-19 pandemic and on the print media specifically with the long-term consequences.

RQ1: Did the space devoted to sports in the selected media change during the first wave of the pandemic?

RQ2: What kind of content did the newspapers publish in the period without public sporting events?

RQ3: During 2021 and 2023, after the first wave of pandemic, was the number of sports pages the same as before COVID-19?

The analysis of content published in print media reflects four main categories (journalists, their routines, created and published content, effects) in sports communication studies (Wanta, 2013; Sherwood & Nicholson, 2013). Quantitative content analysis (as defined by Creswell, 2014 and specifically with regard to sports by Gratton & Jones, 2004) was used to answer the research questions. Hypotheses corresponding to the research questions were formed based on the literature review, as follows:

H1: The chosen newspapers would reduce the space they devoted to sports during the first wave of the pandemic.

H2: The information from competitions and the results would be replaced by news about COVID-19, historical topics, and other alternative content.

H3: The number of sports pages would grow after the first wave of the pandemic when sports competitions re-started.

The sample

The sample set consists of nationwide, general circulation, quality newspapers published continuously in the Czech Republic from 2001 until 2023, when this study was completed: *Hospodářské noviny* (published by Economia), *Lidové noviny* (published by Mafra; later in August 2024, the publication was terminated), *Mladá fronta Dnes* (published by Mafra) and *Právo* (published by Borgis). All the newspapers can be considered general circulation, although the first two, *Hospodářské noviny* and *Lidové noviny* are, respectively were a little bit more oriented toward economic and political/cultural topics, respectively. They had in the selected period lower circulations than the other two newspapers. *Mladá fronta Dnes* and *Právo* represent the typical general-circulation newspaper in the Czech Republic. They are the most-read newspapers in the quality-press segment. The selection of the four newspapers is an opportunity to examine not only the situation in 2020–2023 but also changes that have occurred within a more prolonged period from the beginning of the twenty-first century. The other daily newspapers in the Czech Republic are either tabloids or focus on regional reporting. The daily newspaper *Sport* (published by

Czech News Center) was not included because of its specific focus. It differs from the sports sections of the general newspapers.

The research focused exclusively on the Monday editions of the newspapers, which usually summarise the competitions of the previous week and offer the strongest sports content of the whole week. *Lidové noviny*, *Mladá fronta Dnes*, and *Právo* published sports sections every day. *Hospodářské noviny* had already reduced its sports coverage significantly before the pandemic, but it was publishing at least one page devoted to sport, just on Monday.

Methodology

In the first step, this study employed quantitative analysis of sports coverage in daily newspapers during the period from the beginning of March 2020 until mid-May 2020. That period included two weeks of the standard sports season (although COVID-19 had already been diagnosed in the country as of March 1) and two months when professional and amateur sports were completely suspended. Except for Easter Monday, when Czech newspapers are not published, the sample covered ten weeks with ten Monday editions to analyse. For every day of the period, the total number of pages in the newspapers and the number of sports pages were recorded. This was also done for the same period of the preceding year, 2019, to provide a clear comparison with a period not affected by COVID-19.

In the second step, the study focused on the content of the sports sections. It analysed topics published in the sports sections, paying special attention to COVID-19 news. Every article (other than short news reports in graphic formats) was coded according to its predominant theme: 1) content strictly related to the pandemic (news about postponements and cancellations of competitions, the reactions of athletes and sports institutions, and athletes' alternative forms of training); 2) content unrelated to COVID-19 (competitions taking place without any restriction, other current information); 3) 'timeless' content (e.g., historical events, memorable past sporting events, interviews unrelated to the then-actual situation); 4) other content or a mix of different topics without a prevailing theme.

The third step in the process was to determine if the changes in the structure of the newspapers' sports sections were temporary or long-term, as measured during the same ten-week period of the following year, 2021. The same period in the year 2023 was analysed as well. The same quantitative technique, counting the number of sports pages, was used.

Ethical aspects of the study

Before presenting the findings of this study, it is necessary to mention one of its ethical aspects, a potential conflict of interest. During the period under study, I held the post of editor-in-chief of the sports departments of both *Lidové noviny* and *Mladá fronta Dnes*. I declare that I undertook this study exclusively as a researcher employed by the Faculty of Social Sciences at Charles University and I respected all ethical standards for research in every part of it. I used only publicly available information. I did not evaluate any of the editorial strategies of the selected newspapers. All this research can be replicated, and all the findings presented can be verified, as is allowed by the quantitative research method.

FINDINGS

Reduction in the number of sports pages

According to the results of the quantitative analysis, three of the four selected newspapers decided to reduce the number of pages they devoted to sports during the eight critical weeks from mid-March to mid-May of 2020, when sports competitions were postponed or cancelled due to COVID-19. While *Hospodářské noviny* continued to publish one sports page on Monday as usual, the other newspapers, *Lidové noviny*, *Mladá fronta Dnes*, and *Právo*, eliminated almost half of their sports sections.

Before the pandemic, *Právo* regularly offered the most robust sports section of the four newspapers, with an average of seven pages. That number of pages was still published in the two initial weeks of March, the same as the preceding spring of 2019.

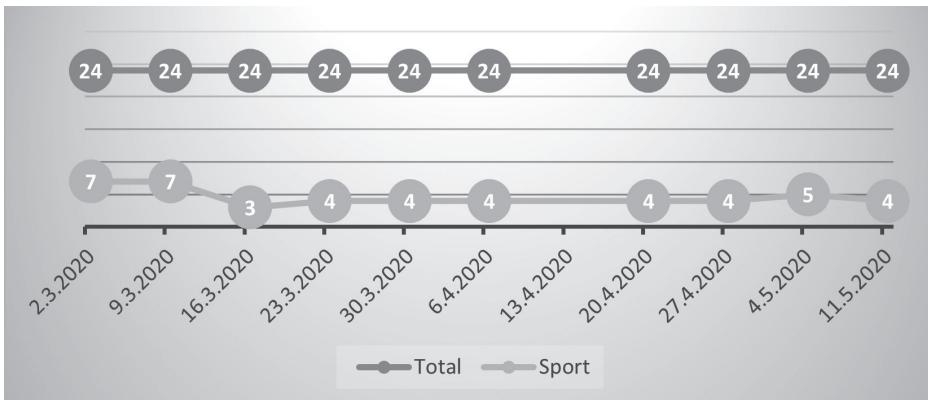

Figure 1 Právo in the Spring of 2020

Sources of data: Own research

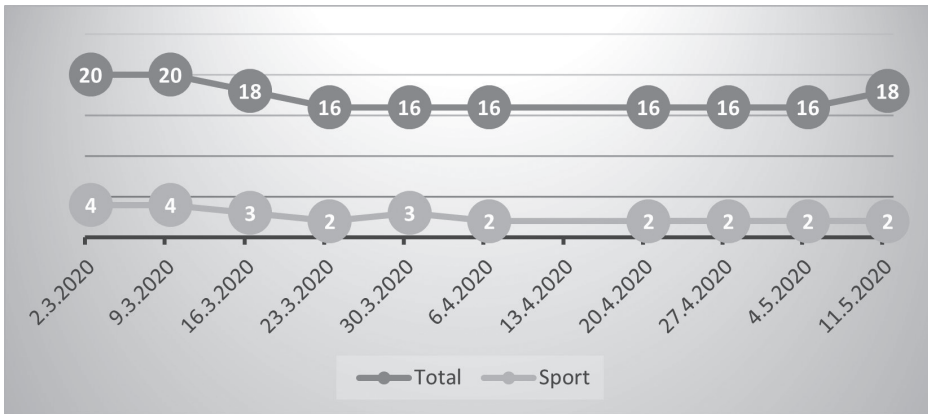

Figure 2 Mladá fronta Dnes in the Spring of 2020

Sources of data: Own research

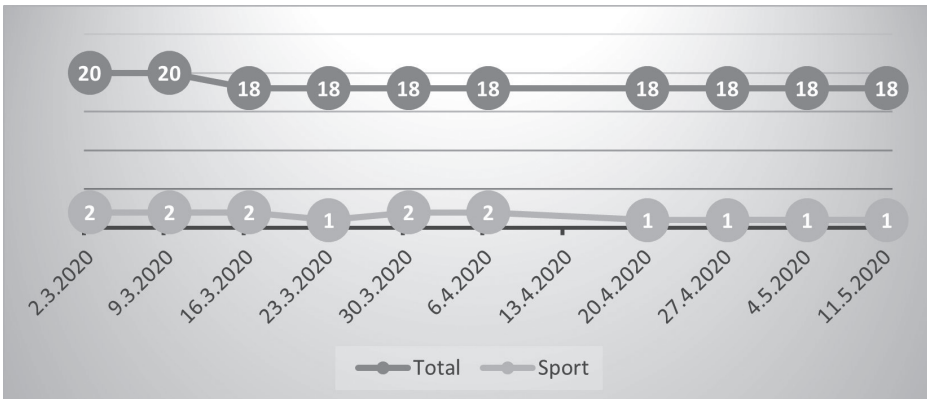

Figure 3 Lidové noviny in the Spring of 2020

Sources of data: Own research

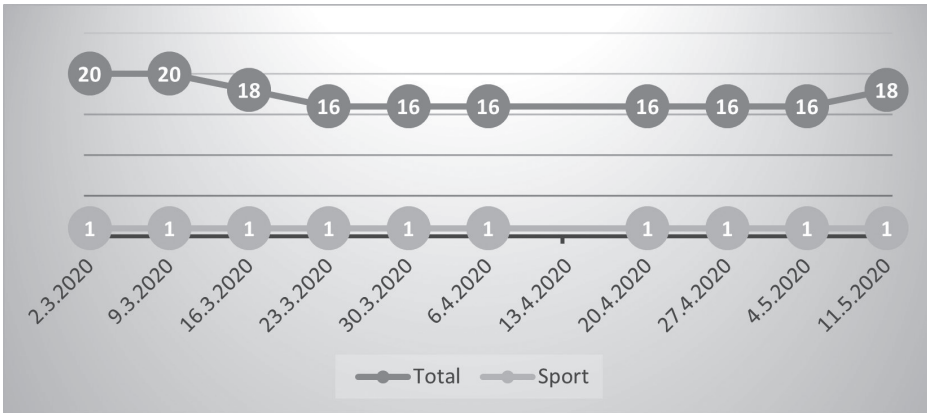

Figure 4 Hospodářské noviny in the Spring of 2020

Sources of data: Own research

Later, when sports competitions had to stop for a couple of months, *Právo* cut only its sports section down to three or more often four pages (Figure 1) but maintained its usual total number of the edition with 24 pages. The newspaper replaced the missing sports content with pages containing other information.

Mladá fronta Dnes normally published four or five sports pages on Monday in the spring of 2019, which made its sports section the second largest of the four newspapers after *Právo*. During the first two weeks of March 2020, it was still publishing four pages of sports, as it had the previous year. When the pandemic started, *Mladá fronta Dnes* downsized its sports section and the total number of pages in their Monday editions as well. The daily reduced its output by two or even four pages from the 20 it was publishing in 2019 and reduced its sports coverage from four or five pages to three, and later to two (Figure 2).

Lidové noviny behaved similarly to *Mladá fronta Dnes*, offering 18 total pages instead of 20 and one or two pages of sport instead of its usual two or even three (Figure 3).

Although *Hospodářské noviny* reacted to the new situation by reducing the total number of pages in its editions from 20 to 18 or even 16, its sports content remained unchanged during the first wave of the pandemic. The single page it normally devoted to sports was still present in every Monday edition despite the lack of regular sports competitions.

Articles on COVID-19, sports history, and hobbies

COVID-19 mainly started to influence the sports sections on Monday, 16 March. The preceding weekend of 14 and 15 March was the first without domestic league play. On the one hand, in *Právo*, *Mladá fronta Dnes*, and *Lidové noviny*, information about ongoing international competitions could be found, for example, the biathlon World Cup and the retirement of the legendary French biathlete Martin Fourcade (LN, 2020a; MFD, 2020a; Právo, 2020a). Furthermore, the dailies discussed the future of the Olympic Games in an interview with the head of the Czech Olympic Committee, Jiří Kejval (Právo, 2020b), the world championship in ice hockey (Právo, 2020c) and the experiences of Czech football players in Italy Antonín Barák and Lukáš Zima (MFD, 2020b; MFD, 2020c), the first European country to be hit by the pandemic.

The following Monday, 23 March, when the ice hockey world championship was cancelled, *Právo*, *Mladá fronta Dnes*, and *Lidové noviny* covered the decision in three different ways: publishing standard news about it (LN, 2020b), interviewing head coach Miloš Říha (Právo, 2020d), and interviewing Říha's assistant Robert Reichel (MFD, 2020d). The other articles published in the four newspapers dealt with the postponement of the Olympic Games and training programs for football players. The match results, tables, and rankings that had been key sports content disappeared almost completely. *Hospodářské noviny*, with its specific form of sports reporting (one page of sport with a single main article, only on Monday), reported on COVID-19's impact on sports. The newspaper analysed the consequences of the pandemic on the economics of football and transfers of football players (HN, 2020a) and talked about how athletes were helping in the crisis (HN, 2020b).

Although the theme of the pandemic stayed at the forefront during the selected period and the number of sports pages decreased in every newspaper, journalists managed to substitute the usual content with content not specifically related to COVID-19, including the postponement or cancellation of certain sports events, stories about athletes, and reflections on the future of sport. The most significant changes were visible in *Právo*. Before the crisis, *Právo* published seven sports pages with more than 25 articles reporting exclusively current information and results. In the spring of 2020, the newspaper's Monday editions sometimes offered only seven or eight articles on four pages, sometimes including one long interview which took up a whole page. For example, in one article the retired tennis player Tomáš Šmíd reminisced about his career (Právo, 2020e). Another special page focused on a retired football player, Josef Csaplár, and a retired coach, Petr Janů, who were spending their time working as lumberjacks (Právo, 2020f).

As the pause caused by hygienic restrictions lengthened to eight weeks, the most memorable past moments in sports became favourite alternative content. *Právo* re-

minded readers of the 1985 World Championship in ice hockey held in Prague (Právo, 2020g) *Mladá fronta Dnes* started to regularly offer a special series entitled "X Years Ago" that included stories about Czech ice hockey players Jaromír Jágr (MFD, 2020e) and Dominik Hašek (MFD, 2020f) in the U.S. National Hockey League in years past. Another article discussed the international perspective on the tragedy of the Torino football team which perished in an air crash in 1949 (MFD, 2020g). The standard content with current information about competitions reappeared in 2021.

Due to the limited space on the single page in which *Lidové noviny* reported sports news, the articles it published in the selected period of 2020 focused on reports based on archived recordings of sports broadcast on TV stations (LN, 2020c) and short reports about e-sports (LN, 2020d). *Hospodářské noviny* characterised e-sports as a strong new trend, not only a result of COVID-19 (HN, 2020c).

Different approaches after the re-start of competitions

One year later, in spring 2021, when the pandemic situation was more stable, *Právo* again offered a full sports section of seven pages on Mondays (Figure 5). Comparing the data from ten weeks in March, April, and May in three consecutive years, 2019, 2020, and 2021, the decrease in sports content appears to be attributable to the suspension of sports competitions in 2020. The structure of the newspapers did not change in 2021 or 2023 compared to 2019.

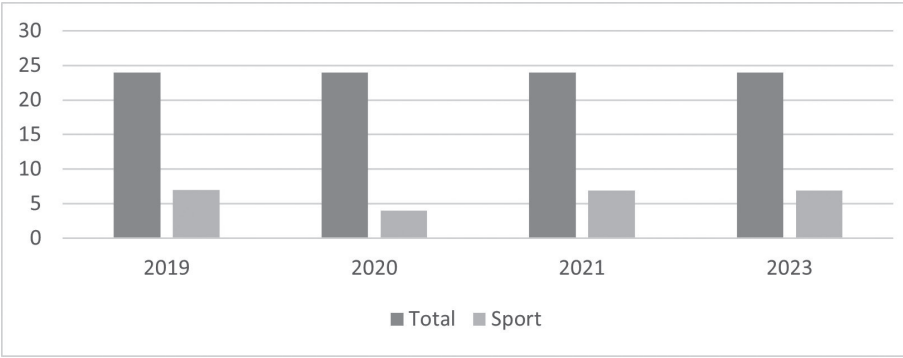

Figure 5 Average Total Pages and Sports Pages in Monday Edition of Právo

Sources of data: Own research

Mladá fronta Dnes did not restore its former structure and continued to publish reduced sports content. In 2021, the total number of pages in Monday edition ranged from 16 to 18, including three sports pages (Figure 6). The sports section later enlarged compared to the period of the first wave of COVID-19, increasing by one page, but it did not return to the size it had before the pandemic, when it had taken up four or five pages. A comparison of *Mladá fronta Dnes*'s reporting in 2019 and 2021 indicates a certain decrease not only in sports coverage, but in the size of the newspaper as a whole. Its sports section recovered proportionally to the other content.

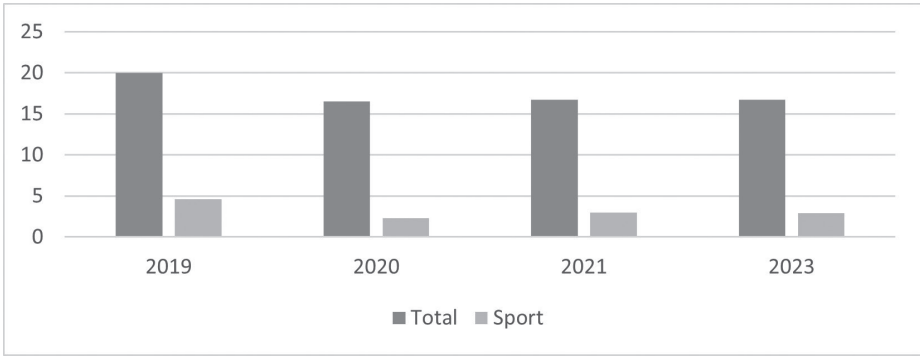

Figure 6 Average Total Pages and Sports Pages in Monday Edition of Mladá fronta Dnes

Sources of data: Own research

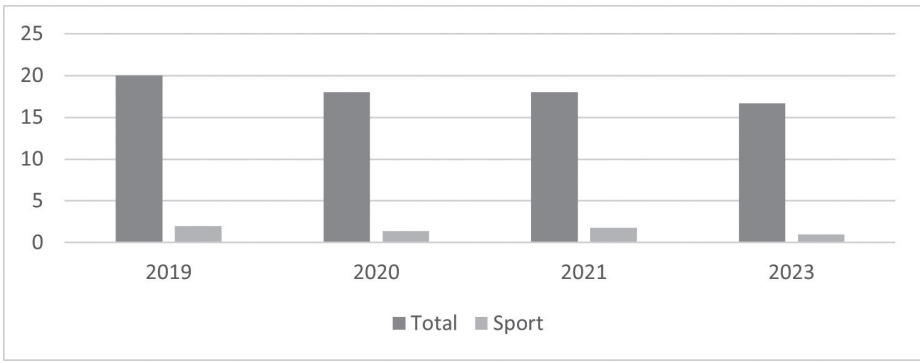

Figure 7 Average Total Pages and Sports Pages in Monday Edition of Lidové noviny

Sources of data: Own research

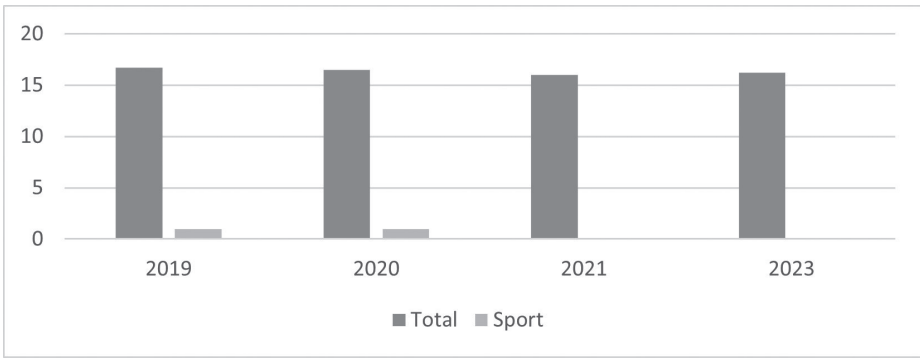

Figure 8 Average Total Pages and Sports Pages in Monday Edition of Hospodářské noviny

Sources of data: Own research

Lidové noviny reduced its overall size, publishing no more than 18 pages instead of the 20 it had published before the pandemic. Two pages, or only one, were devoted to sport in the 2021 period (Figure 7). Comparing the years 2019 and 2021, there was a tiny decrease in the number of pages devoted to sports. A bigger change was evident in the last year of the research, in 2023. Although the total number of pages published in *Lidové noviny* stayed the same, 18, the newspaper normally offered only one page of sports content. That number was even lower than it was during the first wave of COVID-19 when sports competitions were suspended. This represented a lasting change in the newspaper's structure, with sport becoming even more of a niche topic.

A major change took place in the pages of *Hospodářské noviny*. Although this daily newspaper did not downsize its Monday sports section during the first wave of the pandemic, the management decided to eliminate it altogether in the spring of 2021 in the course of a redesign of the newspaper (Mediaguru, 2021). From March 2021, there was no longer any room for permanent, regular, and expectable sports content (Figure 8).

CONCLUSION AND DISCUSSION

The COVID-19 crisis that broke out at the beginning of the year 2020 affected almost the entire world and all domains of human life for many months. Among those domains was sport in all its forms, professional, youth, and amateur. International and domestic competitions were postponed or even cancelled for hygienic reasons. The disappearance of sporting events had a major influence on the media. The consequences of the pandemic on newspaper sports reporting were the primary object of this study, which focused on the Monday editions of *Hospodářské noviny*, *Lidové noviny*, *Mladá fronta Dnes* and *Právo* as representatives of general circulation, quality (non-tabloid) daily newspapers with sports sections published continuously from 2001 to the present.

During the first wave of the pandemic, *Právo* decreased the number of its sports pages from seven in 2019 to four in 2020 and *Mladá fronta Dnes* from four or five pages to only two. In the same period, *Lidové noviny* went from two and sometimes three sports pages to only one. *Hospodářské noviny* preserved its sports section intact from 2019 to 2020, publishing one page on a dominant sports topic. The hypothesis H1, which expected a reduction in the newspapers' sports sections due to the pandemic, was confirmed, except for *Hospodářské noviny*, which already published only a minimum of sports coverage.

The results of competitions and league rankings disappeared from the newspapers and were replaced by articles about COVID-19 and all its consequences or by alternative content, mainly stories from sports history. Hypothesis H2, which predicted the substitution of other stories for regular sports content was also confirmed.

While *Právo* restored its original structure and began again to publish seven pages of sport on Mondays, *Mladá fronta Dnes* remained smaller in size after the pandemic subsided, but the number of its sports pages increased to almost three in its Monday editions. The sports section did not regain its original number of pages, but it did stay proportionally to the total size of the newspaper. However, the sports section in *Lidové noviny* shrank even more in 2023 than it did during the first wave of the pan-

demic. *Hospodářské noviny*, which maintained one sports page during the first wave of the COVID-19 pandemic, eliminated its sports section altogether in the spring of 2021. After that, including in 2023, there was no regular, consistent sports content. Therefore, the research did not confirm Hypothesis H3, that the number of published sports pages would recover after the pandemic.

Právo's temporary reduction of sports content and the subsequent restoration of its original structure can be interpreted as a temporary reaction to an unprecedented situation. But if the reduced total size of the newspaper in the case of *Hospodářské noviny*, *Lidové noviny*, and *Mladá fronta Dnes* became the new standard, it could also suggest there were other reasons for that reduction than simply the shutdown of sporting competitions, the most likely ones being economic (Mediaguru, 2020a; 2020b). Only *Právo* appeared to resist the downsizing trend and the number of sports pages it published remained fairly constant compared to the others. This is the most important finding of the research.

The analysis confirmed that sports content is slowly being reduced or even eliminated from the pages of Czech daily newspapers. Long-term comparisons (Trunečka, 2021) demonstrate that the tendency to downsize sports sections began to appear before that, at the beginning of the twenty-first century, and gained steam after the financial crisis in 2008. The decrease in the size of the sports sections, except for *Právo's*, was significant. *Hospodářské noviny* reduced from five pages in 2009 to one in 2015 and then to zero immediately after the first wave of the pandemic in 2021. *Mladá fronta Dnes* reduced from almost ten pages in 2001 and 2003 to three, and *Lidové noviny* similarly reduced from almost ten pages to two or even just one in 2023.

The COVID-19 pandemic accelerated the rate of decline. From the perspective of the newspaper reader, the sports content published in the Monday editions of the four newspapers in spring 2020 was the least it had ever been since the beginning of the twenty-first century. Disregarding that extreme, exceptional period, the sports content published in 2021 and 2023 was still much reduced compared to the first two decades of the century. The maximum number of sports pages published in the newspapers' Monday editions was far smaller in 2021 and 2023 than it was in previous odd years, particularly in *Hospodářské noviny*, *Lidové noviny*, *Mladá fronta Dnes* (Figure 9).

Because of the very different and more extensive structure of the newspapers at the beginning of the century, with plenty of pages (some of which were transformed into separate magazine sections), it is not possible to compare the proportion of sport to the number of total pages reliably between that period and the present (Trunečka, 2021). However, the absolute number of pages now devoted to sport demonstrates that sports reporting is disappearing little by little from the printed media, mainly in the more specialised newspapers. *Hospodářské noviny* and *Lidové noviny* were rethinking how necessary sports reporting is for them. *Hospodářské noviny*, which has closed down its sports section, is one of several *prominent* daily newspapers that have taken that step (Billings, Butterworth & Turman, 2018). *Lidové noviny* was not far from making the same decision with the only page devoted to sports in 2023, only one year before the announcement of the closure of the newspapers. The general-circulation press (*Mladá fronta Dnes* and *Právo*) may still need to include sports among all the other news it covers.

The results prove that despite the long tradition of newspaper sports journalism and its popularity, which newspapers relied upon in the past to increase their circulation

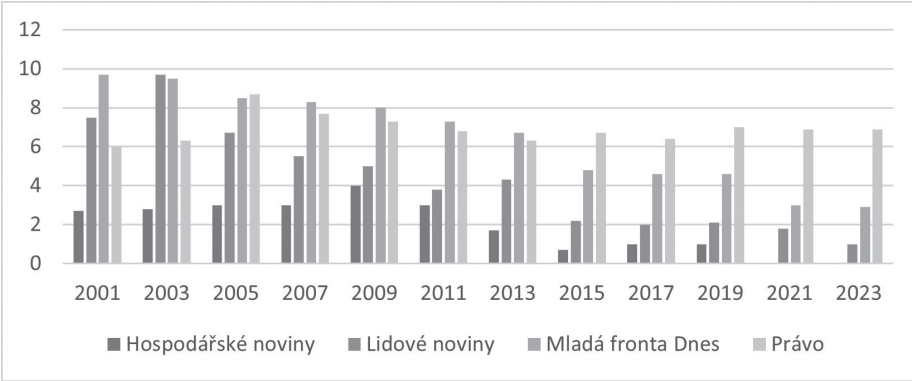

Figure 9 Average Number of Sports Pages in Monday Editions of Daily Newspapers

Sources of data: 2001–2015: Trunečka (2021); 2017–2023: Own research[1]

(Toney, 2014), the future is 'uncertain' (Hodgson, 2020). All this is taking place as the internet is growing in importance as the most popular medium for sports journalism (Real, 2006). Altough traditional sports journalism is more institutionalized than digital forms and kept its specific position centered around a story, while the digital reporting adopted the journalism-as-process model Moritz (2015), the internet sports sites became more perspective mediums. And not only for the supporters as the immediate sources of results, statistics, or match recaps (Billings, Butterworth & Turman, 2018). But as well as the new job for the writers, even if they initially did not plan to work for online outlets (Kian & Zimmerman, 2012). Moreover, it is not possible to ignore the impact of social media, whether they are considered as new competitor to sports journalists, or the relationships between these actors are more diverse (Nölleke, Grimmer & Horky, 2016).

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REFERENCES

Andrews, P. (2017). *Sports Journalism: A Practical Introduction*. London: Sage Publications.

Billings, A. C., Butterworth, M. L. & Turman, P. D. (2018). *Communication and Sport: Surveying the Field*. Los Angeles: Sage.

Biscomb, K. & Matheson, H. (2017). Are the times changing enough? Print media trends across four decades. *International Review for the Sociology of Sport*, *54*(3), 259–281.

[1] It should be noted that the data from 2001 to 2015 (Trunečka, 2021) was averaged over the whole year, while the data for 2019, 2021, and 2023 (own research) was taken from only part of those years. However, the data for all years was reasonably comparable. Data from a missing year, 2017, was added now in this research using the methodology of that study (Trunečka, 2021).

Bradshaw, T., & Minogue, D. (2019). *Sports Journalism. The State of Play*. London: Routledge.
Creswell, J. W. (2014). *Research design: qualitative, quantitative, and mixed method approaches*. Los Angeles: Sage.
Děkanovský, J. (2008). *Sport, média a mýty: zlatí hoši, královna bílé stopy a další moderní hrdinové*. Prague: Dokořán.
Edge, M. (2019). Are UK newspapers really dying? A financial analysis of newspaper publishing companies. *Journal of Media Business Studies*, *16*(1), 19–39.
Gentile, P. C., Buzzelli, N. R., Sadri, S. R. & Arth, Z. W. (2022). Sports Journalism's Uncertain Future: Navigating the Current Media Ecosystem in the Wake of COVID-19 Pandemic. *Journalism Studies*, *23*(10), 1178–1196.
Goldman, M. M. & Hedlund, D. P. (2020). Rebooting Content: Broadcasting Sports and Esports to Homes During Covid. *International Journal of Sport Communication*, *13*(3), 370–380.
Gratton, Ch. & Jones, I. (2004). *Research Methods for Sports Studies*. London: Routledge.
Grix, J., Brannagan, P. M., Grimes, H. & Neville, R. (2020). The Impact of Covid-19 on sport. *International Journal of Sport Policy and Politics*, *13*(1), 1–12.
Hodgson, G. (2020). Newspapers. In: R. Steen, J. Novick & H. Richard (Eds.), *Routledge handbook of sports journalism*. London: Routledge.
Horky, T. (2020). No sports, no spectators – no media, no money? The importance of spectators and broadcasting for professional sport during COVID-19. *Soccer & Society*, *22*(1–2), 96–102.
Hull, K. & Romney, M. (2020). "It Has Changed Completely": How Local Sports Broadcasters Adapted to No Sports. *International Journal of Sports Communication*, *13*(3), 494–504.
Johnson, M. R. & Woodcock, J. (2021). Work, play, and precariousness: An overview of the labour ecosystem of esports. *Media, Culture & Society*, *43*(8), 1449–1465.
Kian, E. M. & Zimmerman, M. H. (2012). The Medium of the Future: Top Sports Writers Discuss Transitioning from Newspapers to Online Journalism. *International Journal of Sport Communication*, *5*(3), 285–304.
McChesney, R. W. (1989). Media and sport: A history of sports coverage in United States. In: L. A. Wenner (Ed.), *Media, Sports, & Society*. Newbury Park: Sage Publications, 49–69.
Moritz, B. (2015). The Story Versus the Stream: Digital Media's Influence on Newspapers Sports Journalism. *International Journal of Sport Communication*, *8*(4), 397–410.
Nölleke, D., Grimmer, C. & Horky, T. (2016). News sources and followed up communication. *Journalism Practice*, *11*(4), 1–18.
O'Sullivan, J., Fortunati, L., Taipale, S. & Barnhurst, K. (2017). Innovators and innovated: Newspapers and the postdigital future beyond the "death of print". *The Information Society*, *33*(2), 86–95.
Pedersen, P. M. (2014). The changing role of sports media producer, 2014. In: A. C. Billings & M. Hardin (Eds.), *Routledge handbook of sport and new media*. London: Routledge, 101–110.
Real, M. (2006). Sports Online: The Newest Player in Mediasport. In: A. A. Raney & J. Bryant (Eds.), *Handbook of Sports and Media*. New York: Routledge, 171–184.
Sadri, S. R., Buzzelli, N. R., Gentile, P. & Billings, A. C. (2022). Sports Journalism Content When No Sports Occur: Framing Athletics Amidst the COVID-19 International Pandemic. *Communication & Sport*, *10*(3), 493–516.
Schallhorn, C. & Kunert, J. (2020). Football without Football: Creativity in German Football Coverage by TV Broadcasters and Clubs during the Coronavirus Crisis. *International Journal of Sports Communication*, *13*(3), 514–522.
Sherwood, M., Nicholson, M. (2013). Research methodologies in sport communication. In: P. M. Pedersen (Ed.), *Routledge handbook of sport communication*. London: Routledge, 98–110.
Toney, J. (2013). *Sport Journalism: The Inside Track*. London: Bloomsbiry.

Trunečka, O. (2017). Kde jsou výsledky, kde popis zápasů? Proměna sportovních rubrik v pondělních vydáních českých deníků [Where are the results and the match recaps? Transformation of sports sections in Monday editions of Czech daily newspapers]. *Studia Sportiva*, *11*(1), 118–125.

Trunečka, O. (2021). *Proměny sportovních rubrik českých deníků v letech 2001 až 2015*. Disertační práce. [The transformation of sports sections of Czech daily newspapers between 2001 and 2015 – Dissertation]. Charles University, Faculty of Social Sciences.

Wanta, W. (2013). Reflections on Communication and Sport: On Reporting and Journalists. *Communication & Sport*, *1*(1/2), 76–87.

Journalistic articles

ČTK, 2020a: ČR má první tři případy nákazy novým koronavirem [The Czech Republic has the first three cases of infection of the new coronavirus]. *ČTK*, 1. 3. 2020.

ČTK, 2020b: Světový pohár v biatlonu bude v Novém Městě bez diváků [The Biathlon World Cup in Nové Město will be held without spectators]. *ČTK*, 2. 3. 2020.

ČTK, 2020c: Slavia remizovala se Spartou 1:1 a vede ligu už jen o osm bodů [Slavia drew with Sparta 1:1 and leads the league by eight points]. *ČTK*, 8. 3. 2020.

ČTK, 2020d: Fotbal a hokej se hrají bez diváků, soutěže jsou ohroženy [Football and hockey leagues without spectators, the future of sports competition is uncertain]. *ČTK*, 10. 3. 2020.

ČTK, 2020e: Sport v Česku se zastaví, vláda zakázala akce nad 30 osob [Sports in the Czech Republic will stop, the government forbidden all events with more than 30 people]. *ČTK*, 12. 3. 2020.

ČTK, 2020f: Sportovní dění v Česku se zastavilo, hokej nepozná mistral [Sports events in the Czech Republic have stopped, hockey league without a new champion]. *ČTK*, 12. 3. 2020.

ČTK, 2020g: Fotbalová liga se znovu rozběhla výhrou Teplic nad Libercem [Football league re-started, Teplice beaten Liberec]. *ČTK*, 23. 5. 2020.

ČTK, 2020h: Dortmund při návratu německé ligy deklasovalo Schalke [The restart of German League: Dortmund outclassed Schalke 4-0]. *ČTK*, 16. 5. 2020.

Mediaguru, 2020a: Pandemie negativně poznamenala prodeje deníků i v dubnu [The pandemic had a negative impact on the sales of newspapers again in April]. *Mediaguru.cz*, 8. 6. 2020.

Mediaguru, 2020b: ONLINE PŘENOS: Dopady koronaviru na média a marketing [ONLINE STREAM: The impact of coronavirus on the media and marketing]. *Mediaguru.cz*, 16. 7. 2020.

Mediaguru, 2021: Hospodářské noviny upravily design, změnit se má i web [Hospodářské noviny have the new design, the website should change too]. *Mediaguru.cz*, 1. 3. 2021.

Mediaguru, 2024: Mafra ukončí vydávání tištěných Lidových novin [Mafra will stop publishing the printed Lidové noviny]. *Mediaguru.cz*, 16. 7. 2021.

Newspapers

Hospodářské noviny. Economia.

Lidové noviny. Mafra.

Mladá fronta Dnes. Mafra.

Právo. Borgis.

Analysed articles

HN, 2020a: Etrych, Š. Konec tučných časů. Co pandemie provede s miliardovým fotbalovým byznysem? [The end of the generous times. What will the pandemic do to billion football business?]. *Hospodářské noviny*, 6. 4. 2020, *31*(68), p. 16.

HN, 2020b: Dubský, V. Sportovci pomáhají [The athletes help]. *Hospodářské noviny*, 30. 3. 2020, *31*(68), p. 16.

HN, 2020c: Káninský, J. Přichází éra digitálního sportu? [Is the era of digital sports coming?]. *Hospodářské noviny*, 20. 4. 2020, *31*(76), p. 16.
LN, 2020a: Vavrda, A. Fourcade vyhrál. A pak se rozloučil [Fourcade won. And then he said goodbye]. *Lidové noviny*, 16. 3. 2020, *33*(64), p. 15.
LN, 2020b: Rampa, R. Hokejový šampionát nebude [There will be no ice-hockey championship]. *Lidové noviny*, 23. 3. 2020, *33*(70), p. 15.
LN, 2020c: Vavrda, A. Televize: Ať žije náš archiv [TV channels: Long live our archive]. *Lidové noviny*, 16. 3. 2020, *33*(64), p. 14.
LN, 2020d: ČTK. Virtuální derby opanovala Sparta [Sparta won the virtual derby]. *Lidové noviny*, 11. 5. 2020, *33*(108), p. 15.
MFD, 2020a: Macek, T. Tak odchází král [Thus the king leaves]. *Mladá fronta Dnes*, 16. 3. 2020, *31*(64), p. 18.
MFD, 2020b: Čermák, D. Sám doma. Jak dlouho? [Home alone. For how long?]. *Mladá fronta Dnes*, 16. 3. 2020, *31*(64), p. 17.
MFD, 2020c: Palička, J. Svatba musí počkat [The wedding has to wait]. *Mladá fronta Dnes*, 16. 3. 2020, *31*(64), p. 17.
MFD, 2020d: Knap, K. Mysleli na finále [They were thinking about the final]. *Mladá fronta Dnes*, 23. 3. 2020, *31*(70), p. 15.
MFD, 2020e: Knap, K. Velký závod [The big race]. *Mladá fronta Dnes*, 6. 4. 2020, *31*(82), p. 15.
MFD, 2020f: Knap, K. Zrození Dominátora [The birth of Dominator]. *Mladá fronta Dnes*, 27. 4. 2020, *31*(98), p. 15.
MFD, 2020g: Palička, J. Den, kdy se Velký Turín ztratil v mlze [The day when the Great Turin was lost in thick fog]. *Mladá fronta Dnes*, 4. 5. 2020, *31*(103), p. 15.
Právo, 2020a: Kézr, M. Fourcade vyhrál a končí. Glóbus má Boe [Fourcade wins and leaves. Boe has the Globe]. *Právo*, 16. 3. 2020, *30*(64), p. 23.
Právo, 2020b: Odoba, M. Odklad her v Tokiu si neumím představit [I can not imagine postponing the games in Toyko]. *Právo*, 16. 3. 2020, *30*(64), p. 22.
Právo, 2020c: Kézr, M. Zrušení MS? Jen věc pojistky [The cancellation of World Cup? Just the question of insurrance]. *Právo*, 16. 3. 2020, *30*(64), p. 22.
Právo, 2020d: Škvor, J. Obrovské zklamání. Ještě jsem věřil [Huge disappointment. I was still hoping]. *Právo*, 23. 3. 2020, *30*(70), p. 21.
Právo, 2020e: Burkert, M. S Beckerem máme pořád hezké vztahy [We have still a good relationship with Becker]. *Právo*, 20. 4. 2020, *30*(92), p. 21.
Právo, 2020f: Neumann, R. Dřevorubec Csaplár [Lumberjack Csaplár]. *Právo*, 11. 5. 2020, *30*(109), p. 24.
Právo, 2020g: Burkert, M. Prahu oslnila zlatá hokejová záře [The golden hockey glow dazzled Prague]. *Právo*, 4. 5. 2020, *30*(103), p. 24.

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Ergonomic implementation of movement interventions in healthcare from the point of view of the physiotherapist

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ABSTRACT

Introduction: Healthcare workers have a high prevalence of musculoskeletal problems, which are often associated with the physical demands of their work, especially with manual handling, lifting and helping patients with mobility. In this paper, we examined these interventions from the physiotherapist's point of view, mainly with the help of biomechanics, and proposed appropriate ergonomic approaches to reduce risks of musculoskeletal disorders.

Methods: We analysed two basic interventions: helping patients to sit over the edge of the bed (starting in the supine position) and helping them to stand up. To determine the safest and most effective methods, we used a combined approach of biomechanics and ergonomics, and we also considered the patient's cooperation in order to train independence and functionality. This approach has also been explained with the help of ergonomic principles.

Results: The optimization of assisting patients to sit over the edge of the bed emphasized minimal lifting, gradual execution, effective rotation of partial centres of gravity, patient activation, use of levers (to use gravity), and rotation instead of lifting. When helping patients to stand up, it is most optimal for the healthcare worker to stand next to the patient, ideally on the side where the patient has preserved better functionality. All the proposed methods have proven to be more ergonomically effective and safe, and allow the patient to gain more independence and functionality.

Discussion: By incorporating the principles of ergonomics and biomechanics, we can reduce the physical burdens of healthcare workers, which does not only improve the safety of healthcare providers, but also increases the safety and independence of patients. Our findings highlight the need to evaluate the relevance of traditional approaches to lifting and handling patients in healthcare.

Conclusion: Incorporation of optimized methods into patient mobility curricula for healthcare professionals is suggested. Policy changes that focus on reducing manual tasks and lifting and include ergonomic interventions can play a key role in reducing work-related musculoskeletal problems.

KEYWORDS
manual handling and lifting; ergonomics; biomechanics; movement interventions; health workers

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INTRODUCTION

In healthcare, interventions often involve physically moving and lifting patients, which has been proven to increase the risk of musculoskeletal issues (Oliveira, et al., 2015). The physical stress resulting from these activities is not only dependent on the mass of the object being moved but also on various other factors, such as leverage, forces and torques, physical condition, and the lifting techniques used (Cimolin, et al., 2016; Haddas, et al., 2016). The term "proper lifting" has been in use for over 100 years, yet traditional approaches to lifting and moving patients have long been criticized (Ravnik, et al., 2017; Ravnik, et al., 2022). Despite a reduction in musculoskeletal issues in heavy industries, these problems have not decreased among healthcare workers, especially nurses, partly due to the traditional educational model (Berman, et al., 2021; Jacob, et al., 2015; Rees Doyle & McCutcheon, 2015). Patient transfers are a significant factor contributing to musculoskeletal issues among healthcare workers, even though nurses spend less than 7% of their time on these activities (Fiedler, et al., 2012). The traditional method is still used in practice in 89% of cases (Ravnik, et al., 2022), highlighting the need for change. It has been proven that ergonomically correct work can significantly reduce musculoskeletal strain (Weißert-Horn, et al., 2014), which is why mechanical moving and lifting are recommended or even mandated by legislation in many countries (Edlich, et al., 2005). An approach that avoids unnecessary lifting has been shown to be highly effective in preventing musculoskeletal issues (Nelson & Fragala, 2004).

METHODS

The aim of this paper is to identify fundamental ergonomic principles and consequently outline the implementation steps for two specific movement interventions. These interventions include assisting a patient in sitting up from a lying position on the back to the edge of the bed and assisting a patient in standing up. The goal is to reduce musculoskeletal strain and work-related musculoskeletal problems among healthcare workers, as well as to promote greater patient independence.

The notion that movement interventions in healthcare can be a risk factor for musculoskeletal issues is not new (Ravnik, 2014). An innovative approach to assisting a patient in standing up was published in 2017 (Ravnik, et al., 2017), and a modified approach to assisting a patient in sitting up on the edge of the bed was introduced

in 2022 (Ravnik, et al., 2022). Both approaches were presented as part of a scientific conference in Slovakia in 2022 (Ravnik, et al., 2022) and a professional meeting of enterostomal nurses in Slovenia in 2024 (Ravnik, 2024). The fundamental requirement for the successful execution of both interventions is the appropriate preparation of both the patient and the healthcare worker. This preparation allows for greater patient activity and independence, as well as successful implementation of some basic ergonomic principles in practice.

Before presenting both approaches graphically, we were interested in the actual state of use of each approach among nursing students. We assessed the frequency of implementation of individual approaches to the intervention of sitting up the patient among nursing students of the Faculty of Health Sciences in Izola, Slovenia. Before the students were introduced to the novel approach, we were interested in how they would sit up the patient themselves. The data were collected through observation during the course of rehabilitation (first year nursing students, bachelor program) from 2017 to 2022. The three approaches observed were the traditional method (A section of Figure 1), its modification with the headboard bent by 25–40 degrees, and the novel approach presented in this article (B section of Figure 1). The results are presented in Table 1.

RESULTS

Table 1 presents the results on the frequency of choosing the implementation of an individual approach to sitting up the patient.

Table 1 Method of implementation of sitting up the patient preferred by nursing students (N = 200)

Traditional method	Modified method	Innovative approach
123	55	22
61.5%	27.5%	11%

The implementation of sitting up the patient with the innovative approach was carried out by only 11% of students, who have all completed a medical high school programme (they have all been educated to the level of nursing assistant previously). All who chose this approach were part-time students, i.e. students with some practical experience.

Sitting on the edge of the bed starting from a lying position (Ravnik, et al., 2022; Ravnik, 2023)

The bed height for sitting must be such that the patient, when lying down, is 20 cm below the elbow height of the healthcare worker (ergonomic rule for heavy work) or so that the patient's pelvis is at the level of the healthcare worker's navel when sitting.
Steps (refer to Figure 2 for assistance):

The patient is lying on their back.

1. The patient bends their legs – this creates leverage (the healthcare worker will then pull the patient's knees towards themselves, rotating the lower part of the torso).

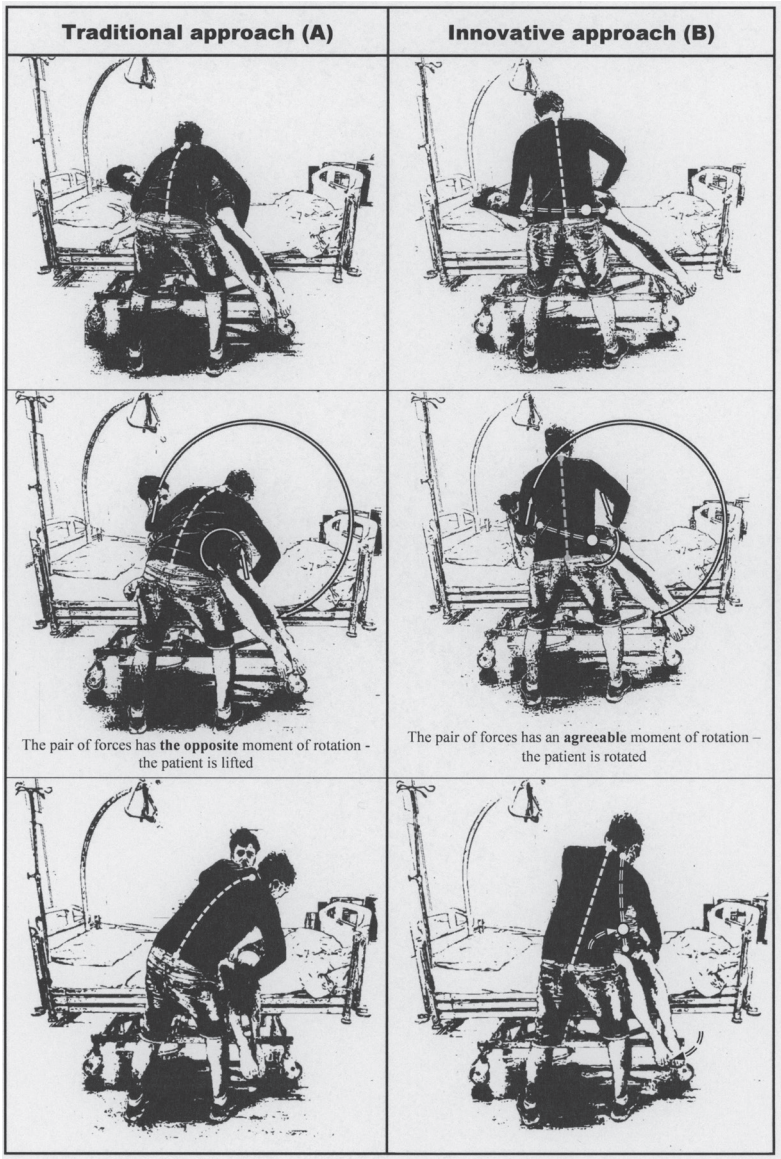

Figure 1 Assisted patient transition from supine to sitting (Ergonomic analysis – biomechanical model)

Legend:

	• Axis of the therapist's axial system
	• The direction of the therapist's force action on the patient's body segments and their rotational effect
	• Axis of the patient's axial system
	• Direction of movement of the patient's body segments (rotation and translation)
	• Patient's approximate COG position

2. The patient clasps one hand with the other and moves them to the side where the healthcare worker is standing (the healthcare worker helps by pulling the hands towards themselves via the patient's wrist, rotating the upper body).
3. The result of steps 1 and 2 is that the patient is turned onto their side.
   The patient is lying on their side.
1. The patient's legs are pulled over the edge of the bed so that they hang slightly off, creating leverage where gravity will help in sitting up the patient.
2. The healthcare worker places one hand under the patient's shoulders and the other on the iliac crest. This hand then pushes the pelvis downwards, achieving pelvis

Figure 2 Sitting on the Edge of the Bed (a – leg rotation, b – torso rotation, c – legs' weight, d – pressure on the pelvis, e – supporting force) (Ravnik, 2023)

rotation and consequently sitting up the patient. The hand on the shoulder only guides and minimally lifts (assisting rotation rather than directly lifting).
3. The result of steps 1 and 2 is that the patient is sitting on the edge of the bed (the bed is still in a high position).

Comparison of transition from lying to sitting

The essential differences between the traditional approach and the innovative approach are shown in Table 2.

Table 2 Differences between approaches A and B

Feature	Traditional approach (A)	Innovative approach (B)
Healthcare worker		
Spine	forward/deviated/rotated	mostly straight
Grip	under the legs; the latter are pulled and lifted over the edge of the bed	one hand under the shoulders, the other in the pelvic area
Pressure/force	simultaneously lifting the torso and lifting and pulling the legs over the edge. The pair of forces has **the opposite** moment of rotation – the patient is lifted	rotation of the COG by pressing the pelvis in the direction of rotation and a slight assistance in raising the trunk. The pair of forces has an **agreeable** moment of rotation – the patient is rotated
Work in planes	simultaneously in transverse and frontal	first in the transverse, then in the frontal
The center of attention	whole body	COG
Stability/balance	Medium	High
Consideration of ergonomics and safety	Medium	High
Patient		
Rotation to the side	passive (with the healthcare worker's help)	active (via a longer handle – a lever)
Legs over the edge	done by the healthcare worker	with bent legs, the higher leg pushes the one on the bed towards the edge
Trunk muscle activity	Medium	High
Consideration of independence and safety	Medium	High

Table 3 Argumentation for a different approach when assisting the patient from the supine to the sitting position

Argument	Question	Discussion
"Turn around independently or by using a lever over the knees and shoulders"	How do I achieve turning in bed with as little effort and as clear instructions as possible?	The lying patient bends his knees (this gives us a lever for rotating the pelvis to the side) and with one hand pulls the other arm towards the therapist (this gives us a lever for rotating the upper part of the torso)

Argument	Question	Discussion
"Put your feet over the edge of the bed"	How to get the weight of the legs to help when sitting down?	When lying on your side, the foot of the upper leg is behind the foot of the lower leg. When attempting to extend, the result is that both legs go over the edge and leverage is achieved
"Bed height high"	At what height of the bed should I perform sitting?	As it is a difficult job, the object of work (COG of the patient) must be kept at a height of 10–20 cm below elbow height
"Rotate the center of gravity (COG) of the load in the main direction – down – to the floor"	How do I achieve trunk lift with as little lifting as possible?	By pressing down on the guttural crest, we achieve COG rotation, which initiates the lifting of the trunk into a sitting position, while at the same time slightly assisting the moment of force over the shoulders in the direction of sitting

Standing up from the bed (Ravnik, et al., 2017)

The bed height for standing up must be such that the patient has both feet on the floor and knees bent at 90–100 degrees.

Steps (refer to Figure 3 for assistance):

The patient is sitting on the edge of the bed.

1. The patient has their feet on the floor and pulls them slightly under the bed – this moves the support surface closer to the projection of the center of gravity on the floor (COG) – the COG is otherwise located at the level of the second sacral vertebra, and its projection at this stage is near the heels on the floor.
2. The patient loads their feet, moves the torso forward and slightly upward, and straightens the knees – this transfers the COG over the support surface and the patient stands up. As long as the projection of the COG on the ground is within the support surface area, the patient will be stable.
3. The result of steps 1 and 2 is that the patient stands up.

Figure 3 Standing up from a sitting position (arrow – direction of COG transfer) (Ravnik, 2023)

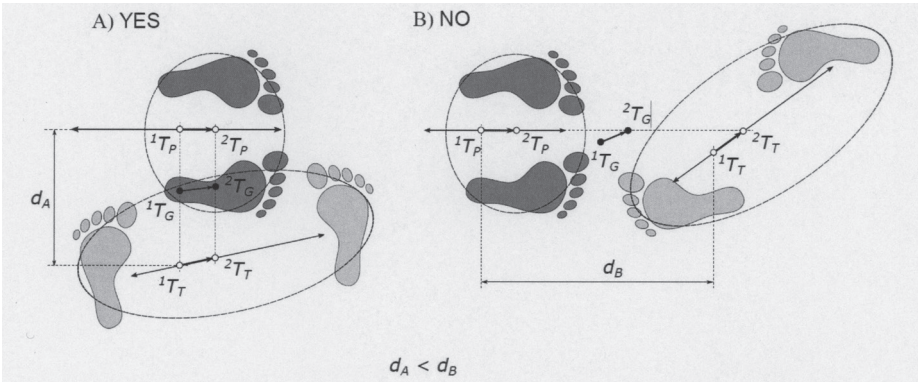

Figure 4 Foot orientation and movement of COGs (floor projection) (Ravnik, et al., 2017)

Legend:
Index *1* – initiating movement, index 2 – completion of movement,
Black feet – patient, grey feet – therapist
TP – projection of COG of the patient to the flatness of the floor
TT – projection of COG of the healthcare worker to the flatness of the floor
TG – projection of the common COG (patient and healthcare worker) to the flatness of the floor (approximately equal weight of both individuals)
dA, dB – distance of projection of COG of the patient and healthcare worker **dA < dB**

If a healthcare worker is assisting with standing up, they should stand next to the patient, grasping the patient's hand with a "thumb-to-thumb" grip with their outer hand, and placing their inner hand under the patient's shoulder (without gripping). The healthcare worker fixes the patient's foot and knee (the leg next to the healthcare worker) with their outer leg. When assisting with standing up, the healthcare worker only helps the patient move their COG forward and slightly upward.

Figure 4 presents the difference in force transmission depending on the position of the healthcare worker (whether he is standing in front of the patient or at his side – which is more optimal for controlling the transfer of COP above the feet and also from the point of view of weight transfer forward when standing up – greater functionality of the patient and more learning of independence).

Arrows indicate the direction of displacement of each projection of COG to the flatness of the floor.

Ovals approximately define the area where it is possible to approach individuals with relative stability.

DISCUSSION

Despite the traditional methods being taught based on the standard approaches to manual handling and lifting, these approaches often prove ineffective in reducing health issues (Nelson & Baptiste, 2004). Therefore, it is important to emphasize the significance of basic preparations for work, such as adjusting bed height, correct positioning of the assisting person, clear instructions for the patient, and proper execution of the procedure as described earlier in the article. When performing interventions, such as assisting a patient to sit on the edge of the bed, healthcare workers can choose to use traditional

methods or opt for an optimized or innovative approach, more commonly utilized by physiotherapists (Ravnik, et al., 2022; Ravnik, 2023). It is crucial for healthcare workers to be educated about the modern methods that can lead to better outcomes in reducing musculoskeletal loads and issues when working with patients. Given the high prevalence of musculoskeletal problems among healthcare workers, it would be sensible to carry out ergonomically inappropriate interventions only as slowly and thoughtfully as possible, relying heavily on patient assistance. Research indicates that employees with a history of back pain tend to perform lifts in a manner that is slower and more similar to a squat, compared to workers without such a history (Saraceni, et al., 2021).

During the transition of a patient from the lying to the sitting position, greater active participation from the patient is desirable, with minimal lifting from healthcare workers utilizing biomechanics, particularly COG rotation. In this scenario, the patient is facilitated in rotating COG on one side using the weight of their legs and activating trunk muscles in response to the pressure applied by the healthcare worker on the pelvis in a downward rotational direction on the other side. This contributes to a gradual transition into a sitting position.

In summary, both approaches can be illustrated with the example of picking up a rake, where the task is to "position the rake handle so we don't need to bend over". Traditionalists would achieve this by picking up the rake by bending over to grasp the handle and lift it (Figure 5a), whereas innovators would pick up the rake by stepping

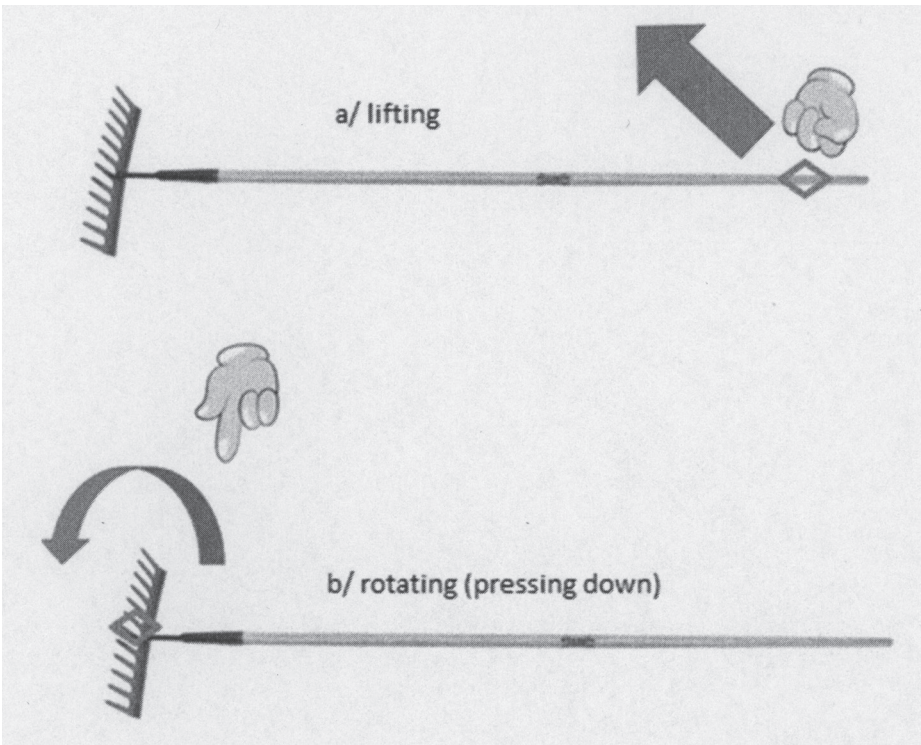

Figure 5 Lifting or pressing down (near-axis rotation) – same effect – diamond is the point of grip (a) or pressure (b)

on the head of the rake – pressing the latter into the ground (Figure 5b). In this second approach, we push downward and are not in a forced position. From an ergonomic perspective, the second approach is more effective because two different directions of force application create the same rotational effect.

Kamiya (2005) described the connection between their proposal for standing up and the movement of older patients. The same movement as proposed by Kamiya can be achieved with an approach where the healthcare worker stands next to the patient, similar to our approach. Trunk inclination additionally reduces the load on the knees during standing up (Fisher, et al., 1990), which is beneficial when assisting older adults with weaker leg strength. The described transition from a seated to a standing position mostly occurs without the use of aids. Literature mentions belts that are placed around the patient's hips to facilitate gripping by nurses (Gagnon, et al., 1988), although this activity is usually not performed by a single healthcare worker. In the 1990s, nurses began using kidney belts to protect the back during lifting, although there was no evidence supporting this approach (Wassell, et al., 2000). When preventing musculoskeletal problems, tools and devices such as mobile and ceiling lifts have proven effective (Yassi, et al., 2001). The use of a bed that allows lateral tilt (right/left) can reduce the risk when assisting patients in bed, as healthcare workers are not forced to lean over the bed and can have a better grip.

All educational institutions should prepare healthcare workers for the proper manual handling and lifting of patients. However, most nursing students continue to learn traditional techniques, despite the lack of evidence supporting their use in practice. Some of these techniques can even be dangerous for both the patient and the healthcare worker (Corlett, et al., 1993). Therefore, it is crucial to reduce manual lifting and use scientifically proven approaches. It is also important to establish good evaluation protocols, such as OWAS (Ovaco Working Posture Analysis System) for measuring physical stress (Engels, et al., 1998), and to include ergonomic programs in educational programs, collaborate with experts in physiotherapy and ergonomics, and implement programs to improve the working environment in healthcare institutions at all levels of education. In Slovenia, there are some practical educational programs that are part of legally mandated health promotion in the workplace and are compliant with current legislation (Ravnik, 2013; Ravnik & Kocjančič, 2015). On the other hand, the impact of physical fitness (conditioning, abilities) on work in healthcare and consequently on musculoskeletal problems should also be examined. Physical activity at work, especially appropriate physical conditioning, has been effective in preventing injuries in industry (Ravnik & Kocjančič, 2015) and in healthcare (Jakobsen, et al., 2015).

CONCLUSION

It is important for healthcare workers to develop good posture and physical fitness and to avoid unnecessary manual lifting, which can cause injuries. Proper education and practice are crucial, especially for nurses who need to be properly trained to avoid incorrect lifting techniques. It is necessary to reduce manual lifting using mechanical aids, also due to the aging working population. It would make sense to use similar approaches to analyze the majority of movement interventions in health care, which could result in reducing the workload of employees and also increasing the indepen-

dence of patients. It is clear from the paper that individual movement interventions can be carried out in several ways, and which is more optimal has been shown by recent research. Therefore, it is important to plan and prepare the working environment, the mutual arrangement, the force used or the device, if necessary, the use of an appropriate approach and, last but not least, the patient's activity in the direction of functionality should also be considered. These modified approaches should also be introduced into the education of health professionals and the curricula of healthcare schools.

REFERENCES

Berman, A., Snyder, S., Frandsen, G. (2021). *Kozier & Erb's Fundamentals of Nursing: concepts, process, and practice*. 11th. ed. Published by Pearson.

Cimolin, V., Cau, N., Tacchini, E., Galli, M., Rigoldi, C., Rinolfi, M., Aspesi V., Capodaglio, E. M., Capodaglio, P. (2016). Spinal load in nurses during emergency lifting of obese patients: preliminary results. *Med. Lav.*, *107*(5), 356–363.

Corlett, E., Lloyd, P., Tarling, C., Troup, J. D. G., Wright, B. (1993). *The guide to handling patients* (3rd edition). London, UK: National Back Pain Association and the Royal College of Nursing.

Edlich, R. F., Hudson, M. A., Buschbacher, R. M., et al. (2005). Devastating injuries in healthcare workers: description of the crisis and legislative solution to the epidemic of back injury from patient lifting. *J. Long-Term Eff. Med. Implants*, *15*, 225–241.

Engels, J. A., van der Gulden, J. W., Senden, T. F., Kolk, J. J., Binkhorst, R. A. (1998). The effects of an ergonomic-educational course. Postural load, perceived physical exertion, and biomechanical errors in nursing. *Int. Arch. Occup. Environ. Health*, *71*(5), 336–342.

Fiedler, K. M., Weir, P. L., van Wyk, P. M., Andrews, D. M. (2012). Analyzing what nurses do during work in a hospital setting: a feasibility study using video. *Work Read. Mass*, *43*(4), 515–523. https://doi.org/10.3233/WOR-2012-1419.

Fisher, N. M., Pendergast, D. R., Calkins, E. C. (1990). Maximal isometric torque of knee extension as a function of muscle length in subjects of advancing age. *Arch. Phys. Med. Rehabil.*, *71*(10), 729–734.

Gagnon, M., Roy, D., Lortie, M., Roy, R. (1988). Evolution of the execution parameters on a patient handling task. *Trav. Hum.*, *51*, 193–210.

Haddas, R., Yang, J., Lieberman, I. (2016). Effects of volitional spine stabilization on lifting task in recurrent low back pain population. *Eur. Spine J. Off. Publ. Eur. Spine Soc. Eur. Spinal Deform. Soc., Eur. Sect. Cerv. Spine Res. Soc.*, *25*, 2833–2841.

Jacob, A. R. R., Tarachand, J. S. (2015). *Clinical Nursing Procedures: The Art of Nursing Practice*. Publisher: Jaypee Brothers Medical Pub., 717 p.

Jakobsen, M. D., Sundstrup, E., Brandt, M., Jay, K., Aagaard, P., Andersen, L. L. (2015). Physical exercise at the workplace prevents deterioration of work ability among healthcare workers: cluster randomized controlled trial. *BMC Public Health*, *15*(1), 1174.

Kamiya, K. (2005). Development and evaluation of life support technology in nursing. *Procedings of the 7th RACE Symposium Research into Inteligentl Artifacts for the Generalization of Engineering*. Chiba, pp. 116–121.

Nelson, A., & Baptiste, A. S. (2004). Evidence-based practices for safe patient handling and movement. *Online J. Issues Nurs.*, *9*(3).

Nelson, A., & Fragala, G. (2004). Equipment for safe patient handling and movement. In: W. Charney, & A. Hudson (Eds.), *Back injury among health care workers: Causes, solutions, and impact*. Boca Raton, FL: Lewis Publishers, pp. 121–135.

Oliveira, V. C., Ferreira, M. L., Refshauge, K. M., Maher, C. G., Griffin, A. R., Hopper, J. L., Ferreira, P. H. (2015). Risk factors for low back pain: insights from a novel case-control twin study. *Spine. J. Off. J. North Am. Spine Soc.*, *15*(1), 50–57.

Ravnik, D. (2013). Applicative ergonomy and physiotherapiology as basics of workplace health promotion. In: D. Železnik, M. B. Kaučič, U. Železnik (Eds.), *The present and future of health scinces in times of global changes*. Slovenj Gradec, Slovenia: University College of Health Sciences Slovenj Gradec, pp. 115–122.

Ravnik, D. (2014). Critical view about different approaches with patient handling. In: D. Železnik, U. Železnik, S. Gmajner (Eds.), *The importance of competent treatment of users of health and social activities in times of crisis* (pp. 292–297). Slovenj Gradec, Slovenia: University College of Health Sciences Slovenj Gradec.

Ravnik, D. & Kocjančič, J. (2015). Effectiveness of preventive and curative ergonomy interventions in work environment in support maritime services. *Prac. Lek.*, *67*(3–4), pp. 92–101.

Ravnik, D., Vrany, J., Jelen, K., Bittner, V. (2017). Biomechanical aspects of assisting patients in standing up in the context of ergonomics. In: A. Zunjić (Ed.), *Ergonomic design and assessment of products and systems*. New York: Nova Science Publishers, pp. 85–103.

Ravnik, D., Bittner, V., Merše Lovrinčević, K. (2022). The intervention of assisting patients to sit over the edge of the bed: presentation of an optimization model. In: M. Valachovičova (Ed.), *The 1st International Scientific Conference: "Quality of Health Care and Patient Safety", November 29th, 2022 Bratislava, Slovak Republic*. Faculty of Nursing and Professional Health Studies of the Slovak Medical University in Bratislava, pp. 81–92.

Ravnik, D. (2023). Kritičen pogled na izvedbo gibalnih intervencij v zdravstveni negi. In: S. Stritar, R. Rajnar (Eds.), *Skrb zase kot uvod h kakovostni obravnavi nevrološkega pacienta : zbornik prispevkov z recenzijo : [19. strokovno srečanje Sekcije medicinskih sester in zdravstvenih tehnikov v nevrologiji] : Ljubljana, 24. november 2023*. Ljubljana: Zbornica zdravstvene in babiške nege Slovenije – Zveza strokovnih društev medicinskih sester, babic in zdravstvenih tehnikov Slovenije, Sekcija medicinskih sester in zdravstvenih tehnikov v nevrologiji, pp. 29–39.

Ravnik, D. (2024). Ergonomija na delovnem mestu : izvedba gibalnih intervencij v zdravstveni negi s pogleda fizioterapevta = Ergonomics in the workplace : implementation of movement interventions in healthcare from the point of view of the physiotherapist. In: R. Batas (Ed.), *Kompleksnost multidisciplinarne obravnave v enterostomalni terapiji – rane, inkontinenca, stome : zbornik prispevkov z recenzijo : Zreče, 19.–20. april 2024*. Ljubljana: Zbornica zdravstvene in babiške nege Slovenije – Zveza strokovnih društev medicinskih sester, babic in zdravstvenih tehnikov Slovenije, Sekcija medicinskih sester v enterostomalni terapiji, pp. 94–103

Rees Doyle, G., McCutcheon, J. (2015). *Clinical Procedures for Safer Patient Care*. Victoria, BC: BCcampus.

Saraceni, N., Campbell, A., Kent, P., Ng, L., Straker, L., O'Sullivan, P. (2021). Exploring lumbar and lower limb kinematics and kinetics for evidence that lifting technique is associated with LBP. *PloS One*, *16*(7), e0254241. https://doi.org/10.1371/journal.pone.0254241.

Wassell, J. T., Gardner, L. I., Landsittel, D. P., Johnston, J. J., Johnston, J. M. (2000). A prospective study of back belts for prevention of back pain and injury. *JAMA*, *284*(21), 2727–2732.

Weißert-Horn, M., Meyer, M. D., Jacobs, M., Stern, H., Raske, H.-W., Landau, K. (2014). "Ergonomisch richtige" Arbeitsweise beim Transfer von Schwerstpflegebedürftigen. *Zeitschrift für Arbeitswissenschaft*, *68*(3), pp. 175–184. https://doi.org/10.1007/BF03374443.

Yassi, A., Cooper, J. E., Tate, R. B., Gerlach, S., Muir, M., Trottier, J., Massey, K. (2001). A randomized controlled trial to prevent patient lift and transfer injuries of health care workers. *Spine*, *26*(16), 1739–1746.

Changes in dual energy X-ray absorptiometry body composition scores in females following exercise-induced body fluid redistribution

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ABSTRACT

Objectives: The aim of the study was to determine changes in dual energy X-ray absorptiometry (DXA) body composition scores in females following exercise-induced body fluid redistribution.

Methods: Thirty females completed sessions of upper-body exercise (UBE), lower-body exercise (LBE), and a seated control (NEC), and body composition was assessed before and after sessions. ANOVA computed interactions between experimental conditions and body composition measurements.

Results: For the arms region, fat tissue showed mean differences for NEC ($M = 0.56 \pm 0.20\%$; $p = 0.009$) and UBE ($M = 0.68 \pm 0.18\%$; $p = 0.001$). The fat region showed mean differences for NEC ($M = 0.54 \pm 0.19\%$; $p = 0.007$) and UBE ($M = 0.59 \pm 0.17\%$; $p = 0.002$). The UBE showed mean differences for tissue ($M = 0.24 \pm 0.03$ kg; $p \leq 0.0001$), lean mass ($M = 0.19 \pm 0.02$ kg; $p \leq 0.0001$), and total mass ($M = 0.24 \pm 0.03$ kg; $p \leq 0.0001$). The legs region showed for UBE a mean difference for fat tissue ($M = 0.32 \pm 0.14\%$; $p = 0.025$), fat region ($M = 0.31 \pm 0.13\%$; $p = 0.026$), and lean mass ($M = 0.17 \pm 0.07$ kg; $p = 0.021$). For the total body region, significant mean differences were found for UBE ($M = 0.11 \pm 0.02$ kg; $p \leq 0.0001$) and LBE ($M = 0.20 \pm 0.03$ kg; $p \leq 0.0001$). Total mass for UBE ($M = 0.14 \pm 0.03$ kg; $p \leq 0.0001$) and LBE ($M = 0.21 \pm 0.03$kg; $p \leq 0.0001$) showed significant mean differences. Reliability scores were high within experimental conditions (CV = 0.17% to 3.76%).

Conclusion: Exercise-induced body fluid redistribution in females elicited small and reliable changes in body composition scores.

KEYWORDS

reliability; body mass; measurement; evaluation; DXA

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INTRODUCTION

The dual-energy X-ray absorptiometry (DXA) technology is available for body composition monitoring in clinical and non-clinical populations. Bone mineral content, lean mass for the entire body, and particular anatomical locations are some of the variables frequently examined at a minimal radiation dose and scanning time (Messina et al., 2015; Nana et al., 2015). DXA is considered a gold standard for bone mineral density and is commonly used for body composition assessment, yet biological and technical errors affect the validity and reliability of the scores (Messina et al., 2020). Among the biological variables that might impact body composition scores assessed by DXA are food and drink consumption before a scanning, unsuitable resting, and hydration (Nana et al., 2015). Current evidence (Chacón-Araya et al., 2024; Karahan et al., 2016; McNamara et al., 2015; Messina et al., 2020; Messina et al., 2015) suggests that technical errors can occur due to inaccurate equipment calibration, unreliable technician performance, patient positioning, image data analysis, artifacts such as coins, keys, or jewelry, clothing's fabrics, and the DXA's equipment scanning mode. Since no specific standard DXA scanning protocol exists, good practices have been recommended (Hume et al., 2018). Under these suggestions, individuals undergoing scanning should arrive at a testing site fasted and at rest since prior meals and physical activity increase errors in DXA measurements (Messina et al., 2020; Nana et al., 2015).

The evidence on the potential noise of food and drink consumption before DXA scans are controversial; it is necessary to conduct a meta-analysis to determine the magnitude if any, of the effect of food intake hours or minutes before a body composition assessment using DXA (Kerr et al., 2017; Nana et al., 2015). Physiologically, lean tissue in the human body contains around 73% water (Pietrobelli et al., 1998); thus, blood flow redistribution caused by food intake digestion and physical activity may change X-ray attenuation and, as a result, the reported body composition values might be biased (Toomey et al., 2017). Previous evidence indicates that variations in the hydration status of lean tissue affect DXA results (Fosbøl & Zerahn, 2015); for instance, hydration status had a 1% impact on the accuracy of fat content measurement (Pietrobelli et al., 1998). In clinical patients (Formica et al., 1993; LaForgia et al., 2009), variations in body fluids had no impact on the values of fat mass assessed by DXA. Lean mass responsible for muscular contraction has more water, and fluid shifts before DXA measurements might cause noise and reduce validity; therefore, there must be thoroughly evaluated in controlled studies (Nana et al., 2013).

AIM

With no previous evidence on the effects of acute body fluid redistribution on DXA scores, examining technical mistakes and their magnitude on DXA readings requires more investigation (Nana et al., 2015). Therefore, in a sample of young Hispanic females, this study aimed to evaluate the impact of acute exercise-induced body fluid redistribution on DXA body composition scores. We hypothesized that acute exercise would change body composition scores.

METHODS

Study design

Using a repeated-measures experimental design, body composition as determined by DXA was investigated before (pre) and after (post) each of the three experimental conditions: a) upper-body exercise (UBE), b) lower-body exercise (LBE), and c) non-exercise control (NEC).

Participants

For the study, thirty apparently healthy male college students were recruited. Participants were required to be between 18 and 40 yr. and fit into the densitometer measuring region. The trial was not open to volunteers having a history of metabolic, skeletal muscle-related, or other health problems (Calbet et al., 2001). The research did not include volunteers who were presently smokers, above 272 kg or had recently received radioactive contrast agents (International Society for Clinical Densitometry, 2019; Lewiecki et al., 2016).

Measurement instruments

Body weight (kg) and height (cm) were measured using a Seca ultrasound measuring station, model 256 dp (Chino, CA). Body weight and height measures were accurate within 50 g and 1 mm, respectively. Body mass index (BMI in kg m^{-2}) was then obtained as body weight (kg)/body height (m^2). Body composition was assessed using a DXA machine, General Electric, model Lunar Prodigy Advance (GE Medical Systems Lunar, Madison, WI), and enCORE 2011 software, version 13.60.033. We performed a daily apparatus calibration according to the manufacturer's guidelines as part of the DXA quality control process (Thurlow et al., 2018).

We collected a urine sample and recorded the urine specific gravity (USG) to assess the participant's baseline level of hydration using an Atago (Japan) refractometer, model URC/N, with a graduation range from 1.000–1.050 units. In addition, total body water (TBW) was calculated using a Seca bioelectrical impedance analysis (BIA) equipment, model mBCA 514 (Chino, CA). The BIA analysis was gathered from the hands and feet using a multi-frequency mode.

A Wakeman fitness pedal exerciser, model 80-5113 (Trademark Global, LLC, China), was used for the upper-body exercise experimental condition. On a Cybex recumbent bicycle, model 770R (Cybex International, Inc., Medway, MA), the lower-body exercise experimental condition was conducted. A Polar Electro (Oy, Kempele, Finland) telemetric heart rate (HR) monitor, model FT7, was used to control exercise intensity.

Procedures

Potential volunteers were recruited from all-college requirement physical activity courses. The evaluations were completed at the Body Composition Laboratory at the University of Costa Rica, under stable 22°C and 80% relative humidity conditions. Each participant received a personal appointment and was told to arrive at 7:00 am after a 10-h fast. Participants read and signed an informed consent form already authorized by the University of Costa Rica's Scientific Ethics Committee. Participants next collected a urine sample for refractometer examination. Those whose USG levels

were ≥ 1.020 (Armstrong, 2007; Oppliger et al., 2005), were considered dehydrated and rescheduled for body composition measurements.

In order to evaluate the precision of the measurements that the researchers collected, a precision study was carried out (International Society for Clinical Densitometry, 2019). International standards mandate that a technician conduct an *in vivo* precision study with the target population for all relevant body composition variables. Additionally, to attain statistical power, the International Society for Clinical Densitometry (2019) advises that each technician assess 30 participants twice with repositioning. In order to calculate the precision error, two researchers (EC-R and YC-A) recruited 30 individuals unrelated to the study, scanned them using repositioning, and put the recorded results into the ISCD online calculator. Based on the coefficient of variation for the researchers EC-R (0.4%) and YC-A (< 0.2%), the precision error was judged acceptable.

After taking a deep breath, participants were directed to proceed onto the body height scale while facing the stadiometer with their feet at a 60°, barefoot, upright, and with no shoes. Height and weight were then recorded. Participants were then instructed to get off the scale and position themselves on the BIA apparatus, placing their feet on the platform's electrodes while holding onto the grips next to the electrodes. The operator then began calculating the amount of total body water.

Experimental conditions

The participants completed the three experimental conditions in a random order. For the UBE condition, the participants performed 30-min aerobic exercise on a pedal exerciser apparatus at an intensity of 70% of the reserve HR obtained by the formula: HRR = [(HRmax – RHR) × % intensity] + RHR (American College of Sports Medicine, 2021), where HRR = HR reserve, RHR = resting HR (measured after 10 min rest) and HRmax = maximum HR (208 – 0.7 × age in yr.) (Tanaka et al., 2001). The LBE program included exercising for 30-min on a recumbent bike while maintaining a heart rate of 70%. In the NEC condition, the individual sat still for 30-min without engaging in any physical activity. Participants were not allowed to consume food or beverages while undergoing any of the regimens, and a telemetric HR monitor enabled regulating the exercise intensity.

Body composition assessment

The following seven variables were used to estimate body composition variables in three regions (arms, legs, and total body): fat mass (%), region fat (%), fat mass (kg), fat mass (kg), lean mass (kg), bone mineral content (kg), and total mass (kg). The participant arrived at the assessment site fasted, hydrated, and without exercising the day before to comply with best practices for body composition assessment (Hume et al., 2018). The participant was instructed to be well hydrated (i.e., drink lots of water and eat typical foods) and to refrain from exercising the day before the test to reduce the risk of dehydration and inadequate rehydration to ensure that they met these requirements. Each participant was required to remove any metal jewelry from their person and to dress in athletic attire once the study staff verified these requirements. Afterward, participants were positioned dorsally on the DXA bed and told to keep quiet during the scan. After the initial DXA scan, participants were invited to wear their training clothes. They were then requested to wipe perspiration off their bodies

with towels after the activity before having another DXA scan. As a result, the procedure was carried out twice during the same session – once before the experimental condition (Pre) and once after it (Post). Also, the fluid loss due to dehydration was assessed with the body mass information before and after exercise or non-exercise control condition using the equation: (Final weight in kg – Initial weight in kg). After finishing the second DXA scan, participants were given a standardized breakfast with an energy content of 1570.1 kJ.

Statistical analysis

The IBM-SPSS Statistics program, version 26 (Armonk, NY), was used to calculate the statistical analyses. The mean and standard deviation (M ± SD) described the dependent variables. A 3 × 2 repeated measures ANOVA (3 experimental conditions × 2 measurements) determined significant interactions between experimental conditions and measurements. Fisher's Least Significant Difference (LSD) *post hoc* test followed-up significant interactions, and the 95% confidence interval ($CI95\%_{diff}$) for the mean differences were also reported.

The magnitude of the observed effects was calculated as partial eta-squares (η_p^2) and were interpreted as small (0.01), medium (0.06), and large (0.14) (Cohen, 1988). For all inferential analysis, the statistical significance was set *a priori* at $p < 0.05$. The absolute reliability in body composition scores was studied by the typical error of the measurement (TEM) and the coefficient of variability (CV[%]) (Currell & Jeukendrup, 2008). The smallest worthwhile change (SWC) in body composition scores was computed as $SWC = TEM \times \sqrt{2} \times 0.2$ (Hopkins, 2000).

RESULTS

Participants

Volunteers were 30 female college students (age = 19.78 ± 1.74 yr., weight = 57.0 ± 9.4 kg, height = 159.2 ± 6.4 cm, BMI = 22.4 ± 3.3 kg m^{-2}. The BIA-derived TBW for the NEC (29.1 ± 3.58 L), UBE (29.1 ± 3.44 L), and LBE (29.2 ± 3.61 L) were insignificant ($p = 0.748$). Descriptive and inferential statistics for arm and leg segments and total body before and after the experimental conditions are presented in table 1.

Body fluid changes

The body fluid loss as determined by the difference from pre to post were significant for total mass for NEC (0.05 ± 0.18 kg), UBE (0.14 ± 0.17 kg), and LBE (0.21 ± 0.19 kg) ($p = 0.004$; $\eta_p^2 = 0.17$). Post-hoc analyses showed significant mean differences between NEC and UBE ($CI95\%_{diff}$ = –0.19 to –0.01 kg), and NEC and LBE ($CI95\%_{diff}$ = –0.26 to –0.06 kg). Insignificant mean differences were observed between UBE and LBE ($CI95\%_{diff}$ = –0.16 to 0.03 kg).

Body composition changes

Statistically significant interactions were found in the arms and legs regions in five out of seven body composition scores following the experimental conditions. For the total body, significant interactions were found in two out of seven body composition scores following experimental conditions (Table 2).

Table 1 Descriptive and inferential statistics of body composition variables by anatomical region in individuals undergoing three experimental sessions (n = 30). The statistical significance ($p \leq$) is shown between pre- and post-test of each experimental condition.

Region	Non-Exercise Control			Upper-Body Exercise			Lower-Body Exercise		
	Pre	Post	$p \leq$	Pre	Post	$p \leq$	Pre	Post	$p \leq$
Arms									
Tissue fat (%)	31.46 ± 7.47	32.02 ± 7.42	0.009	31.51 ± 7.00	30.84 ± 7.21	0.001	31.57 ± 7.28	31.57 ± 7.38	1.000
Region fat (%)	30.02 ± 7.25	30.56 ± 7.24	0.007	30.06 ± 6.83	29.48 ± 7.01	0.002	30.15 ± 7.09	30.14 ± 7.19	0.986
Tissue (kg)	5.11 ± 1.08	5.11 ± 1.06	0.991	5.11 ± 1.08	5.34 ± 1.12	0.0001	5.16 ± 1.04	5.18 ± 1.13	0.445
Fat mass (kg)	1.65 ± 0.64	1.67 ± 0.64	0.076	1.64 ± 0.63	1.69 ± 0.66	0.013	1.66 ± 0.64	1.67 ± 0.68	0.505
Lean mass (kg)	3.47 ± 0.65	3.44 ± 0.64	0.174	3.46 ± 0.65	3.66 ± 0.67	0.0001	3.49 ± 0.63	3.50 ± 0.67	0.558
BMC (kg)	0.25 ± 0.05	0.25 ± 0.05	0.266	0.25 ± 0.05	0.25 ± 0.05	0.033	0.25 ± 0.05	0.25 ± 0.05	0.305
Total mass (kg)	5.36 ± 1.11	5.36 ± 1.09	0.902	5.35 ± 1.12	5.59 ± 1.17	0.0001	5.40 ± 1.08	5.43 ± 1.17	0.280
Legs									
Tissue fat (%)	39.75 ± 7.19	39.86 ± 7.05	0.407	39.55 ± 7.21	39.87 ± 7.26	0.025	39.66 ± 7.15	39.52 ± 7.30	0.269
Region fat (%)	38.25 ± 7.01	38.38 ± 6.88	0.258	38.06 ± 7.03	38.37 ± 7.07	0.026	38.16 ± 7.00	38.04 ± 7.14	0.289
Tissue (kg)	1.88 ± 3.55	1.90 ± 3.65	0.060	1.91 ± 3.64	1.89 ± 3.63	0.093	1.91 ± 3.55	1.90 ± 3.55	0.430
Fat mass (kg)	7.62 ± 2.54	7.71 ± 2.59	0.087	7.69 ± 2.63	7.69 ± 2.63	0.935	7.72 ± 2.58	7.40 ± 2.88	0.242
Lean mass (kg)	11.70 ± 1.66	11.24 ± 1.72	0.121	11.36 ± 1.69	11.19 ± 1.69	0.021	11.34 ± 1.65	11.32 ± 1.67	0.769
BMC (kg)	0.74 ± 0.14	0.74 ± 0.14	0.177	0.74 ± 0.14	0.74 ± 0.14	0.331	0.74 ± 0.14	0.74 ± 0.14	0.691
Total mass (kg)	19.54 ± 3.66	19.69 ± 3.77	0.077	19.80 ± 3.75	19.62 ± 3.74	0.081	19.81 ± 3.66	19.73 ± 3.66	0.467
Total body									
Tissue fat (%)	35.77 ± 6.91	35.88 ± 6.77	0.428	35.59 ± 6.73	35.67 ± 6.62	0.523	35.66 ± 6.93	35.75 ± 6.97	0.563
Region fat (%)	34.40 ± 6.69	34.49 ± 6.56	0.440	34.23 ± 6.54	34.33 ± 6.44	0.424	34.30 ± 6.71	34.38 ± 6.76	0.581

Region	Non-Exercise Control			Upper-Body Exercise			Lower-Body Exercise		
	Pre	Post	p ≤	Pre	Post	p ≤	Pre	Post	p ≤
Tissue (kg)	5.37 ± 8.85	5.36 ± 8.85	0.179	5.39 ± 8.92	5.38 ± 8.92	0.0001	5.39 ± 8.80	5.37 ± 8.81	0.0001
Fat mass (kg)	19.55 ± 6.31	19.57 ± 6.18	0.759	18.74 ± 6.88	19.54 ± 6.23	0.319	19.59 ± 6.41	19.57 ± 6.50	0.870
Lean mass (kg)	34.11 ± 4.55	34.04 ± 4.63	0.445	34.37 ± 4.58	33.91 ± 4.87	0.167	34.30 ± 4.36	34.11 ± 4.38	0.106
BMC (kg)	2.14 ± 0.33	2.14 ± 0.32	0.823	2.13 ± 0.32	2.12 ± 0.32	0.431	2.14 ± 0.33	2.10 ± 0.41	0.317
Total mass (kg)	55.80 ± 9.11	55.75 ± 9.09	0.162	56.03 ± 9.16	55.88 ± 9.13	0.0001	56.02 ± 9.05	55.82 ± 9.08	0.0001

Note: BMC = Bone mineral content.

Table 2 Summary statistical significance for the ANOVA model. The conditions are the three experimental sessions and the measurements are assessments before and after the specific session. The interaction term refers to the combination effects of conditions and measurements. Explained variance is presented as partial eta-squared (η_p^2) and is interpreted as small (0.01), medium (0.06), and large (0.14) (Cohen, 1988).

Variable	Source of variance					
	Conditions (A)		Measurements (B)		Interaction (A × B)	
	p ≤	η_p^2 =	p ≤	η_p^2 =	p ≤	η_p^2 =
Arms						
Tissue fat (%)	0.004	0.18	0.747	0.00	0.0001	0.26
Region fat (%)	0.004	0.17	0.870	0.00	0.0001	0.25
Tissue (kg)	0.0001	0.27	0.0001	0.52	0.0001	0.42
Fat mass (kg)	0.734	0.01	0.004	0.26	0.371	0.03
Lean mass (kg)	0.0001	0.37	0.0001	0.53	0.0001	0.58
BMC (kg)	0.635	0.02	0.020	0.17	0.499	0.02
Total mass (kg)	0.0001	0.28	0.0001	0.54	0.0001	0.40
Legs						
Tissue fat (%)	0.279	0.04	0.251	0.05	0.036	0.11
Region fat (%)	0.229	0.05	0.181	0.06	0.032	0.11
Tissue (kg)	0.154	0.06	0.585	0.01	0.031	0.11
Fat mass (kg)	0.453	0.03	0.399	0.03	0.173	0.06
Lean mass (kg)	0.086	0.08	0.275	0.04	0.024	0.12
BMC (kg)	0.855	0.01	0.997	0.00	0.179	0.06
Total mass (kg)	0.141	0.07	0.554	0.01	0.038	0.11
Total body						
Tissue fat (%)	0.321	0.04	0.149	0.07	0.994	0.00
Region fat (%)	0.384	0.03	0.134	0.08	0.998	0.00
Tissue (kg)	0.238	0.05	0.0001	0.62	0.003	0.18
Fat mass (kg)	0.354	0.04	0.327	0.03	0.369	0.03
Lean mass (kg)	0.761	0.01	0.064	0.11	0.370	0.03
BMC (kg)	0.483	0.03	0.276	0.04	0.442	0.03
Total mass (kg)	0.333	0.04	0.0001	0.65	0.004	0.17

Note: BMC= Bone mineral content.

For the arms region, significant interactions were observed on fat tissue, fat region, tissue, lean mass, and total mass (Table 2). Post-hoc analyses for fat tissue showed significant mean differences for NEC of 0.56 ± 0.20% ($CI95\%_{diff}$ = 0.15 to 0.97%) and for UBE of 0.68 ± 0.18% ($CI95\%_{diff}$ = 0.29 to 1.04%). Post-hoc analyses for fat region showed significant mean differences for NEC of 0.54 ± 0.19% ($CI95\%_{diff}$ = 0.16 to 0.92%) and for UBE of 0.59 ± 0.17% ($CI95\%_{diff}$ = 0.24 to 0.93%). Post-hoc analyses for

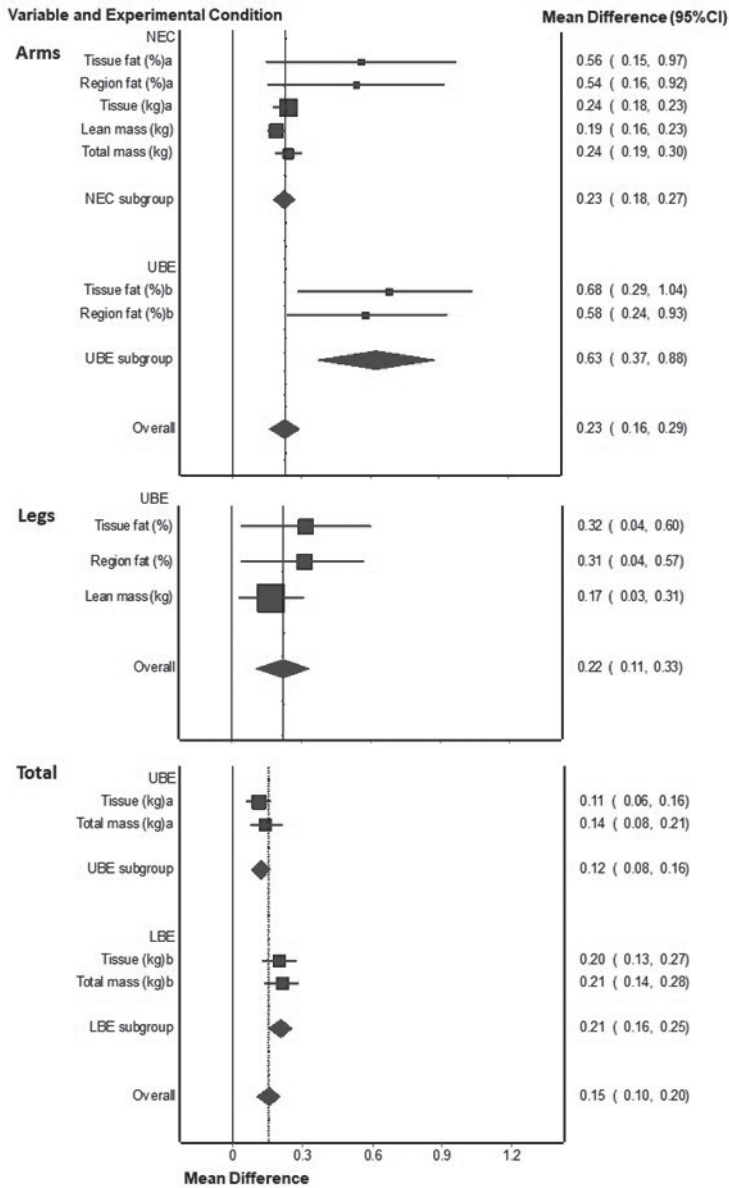

Figure 1 Forest plot of arms, legs, and total body region changes in body composition scores among females completing three experimental conditions: NEC: non-exercise control; UBE: upper-body exercise; LBE: lower-body exercise (n = 30).

Table 3 Absolute reliability (TEM, CV%) and smallest worthwhile change (SWC) of regional body composition scores of college-females completing three experimental sessions (n = 30). TEM and SWC are shown in the original measurement units, and CV is interpreted as small if ≤ 10% (Currell & Jeukendrup, 2008).

Region variable	Non-Exercise Control			Upper-Body Exercise			Lower-Body Exercise		
	TEM	CV (%)	SWC	TEM	CV (%)	SWC	TEM	CV (%)	SWC
Arms									
Tissue fat (%)	0.77	2.43	0.22	0.70	2.26	0.20	0.74	2.36	0.21
Region fat (%)	0.73	2.40	0.21	0.66	2.20	0.19	0.71	2.35	0.20
Tissue (kg)	0.11	2.17	0.03	0.11	2.01	0.03	0.11	2.12	0.03
Fat mass (kg)	0.06	3.50	0.02	0.06	3.85	0.02	0.06	3.76	0.20
Lean mass (kg)	0.08	2.19	0.02	0.07	1.85	0.02	0.07	2.04	0.02
BMC (kg)	0.00	1.90	0.00	0.00	2.23	0.00	0.00	2.00	0.00
Total mass (kg)	0.11	2.13	0.03	0.11	1.99	0.03	0.11	2.10	0.03
Legs									
Tissue fat (%)	0.51	1.27	0.14	0.53	1.34	0.15	0.48	1.22	0.14
Region fat (%)	0.45	1.17	0.13	0.51	1.32	0.14	0.44	1.16	0.13
Tissue (kg)	0.30	1.61	0.09	0.38	2.02	0.11	0.38	1.93	0.10
Fat mass (kg)	0.19	2.50	0.05	0.17	2.22	0.05	1.05	13.89	0.30
Lean mass (kg)	0.16	1.43	0.05	0.27	2.37	0.08	0.26	2.33	0.07
BMC (kg)	0.00	1.19	0.00	0.00	1.13	0.00	0.01	1.30	0.00
Total mass (kg)	0.31	1.59	0.09	0.38	1.95	0.11	0.38	1.94	0.11
Total body									
Tissue fat (%)	0.51	1.44	0.15	0.50	1.40	0.14	0.62	1.73	0.17
Region fat (%)	0.46	1.34	0.13	0.45	1.30	0.13	0.58	1.68	0.16

Region variable	Non-Exercise Control			Upper-Body Exercise			Lower-Body Exercise		
	TEM	CV (%)	SWC	TEM	CV (%)	SWC	TEM	CV (%)	SWC
Tissue (kg)	0.13	0.24	0.04	0.09	0.17	0.03	0.13	0.24	0.04
Fat mass (kg)	0.27	1.39	0.08	3.06	15.97	0.86	0.37	1.88	0.10
Lean mass (kg)	0.34	1.00	0.10	1.25	3.65	0.35	0.43	1.26	0.12
BMC (kg)	0.04	1.64	0.01	0.03	1.48	0.01	0.13	6.31	0.04
Total mass (kg)	0.12	0.22	0.04	0.12	0.21	0.03	0.13	0.24	0.04

Note: BMC – Bone mineral content; TEM – typical error of the measurement; SWC – smallest worthwhile change; CV – coefficient of variability.

UBE showed significant mean differences for tissue of 0.24 ± 0.03 kg ($CI95\%_{diff}$ = 0.18 to 0.23 kg), lean mass of 0.19 ± 0.02 kg ($CI95\%_{diff}$ = 0.16 to 0.23 kg), and total mass of 0.24 ± 0.03 kg ($CI95\%_{diff}$ = 0.19 to 0.30 kg) (Table 1, Figure 1).

For the legs region, significant interactions were observed on fat tissue, fat region, tissue, lean mass, and total mass. Post-hoc analyses for UBE showed significant mean differences for fat tissue of 0.32 ± 0.14% ($CI95\%_{diff}$ = 0.04 to 0.60%), fat region of 0.31 ± 0.13% ($CI95\%_{diff}$ = 0.04 to 0.57%), and lean mass of 0.17 ± 0.07 kg ($CI95\%_{diff}$ = 0.03 to 0.31 kg). Post-hoc analyses for NEC and UBE on total mass pre vs. post were insignificant in spite of the significant interaction. The interaction was explained by the differences in pre-test total mass scores between NEC and UBE (M_{diff} = 0.26 ± 0.01 kg; $CI95\%_{diff}$ = 0.04 to 0.48 kg), and NEC and LBE (M_{diff} = 0.27 ± 0.01 kg; $CI95\%_{diff}$ = 0.06 to 0.47 kg). Also, the post-hoc analyses for NEC and UBE on tissue pre vs. post were insignificant in spite of the significant interaction. The interaction was explained by the differences in pre-test tissue scores between NEC and UBE (M_{diff} = 0.25 ± 0.11 kg; $CI95\%_{diff}$ = 0.04 to 0.47 kg), and NEC and LBE (M_{diff} = 0.27 ± 0.10 kg; $CI95\%_{diff}$ = 0.07 to 0.47 kg) (Table 1, Figure 1).

For the total body, significant interactions were observed on tissue and total mass. Post-hoc analyses of tissue for UBE showed mean differences of 0.11 ± 0.02 kg ($CI95\%_{diff}$ = 0.06 to 0.16 kg) and for LBE of 0.20 ± 0.03 kg ($CI95\%_{diff}$ = 0.13 to 0.27 kg). Post-hoc analyses of total mass for UBE showed mean differences of 0.14 ± 0.03 kg ($CI95\%_{diff}$ = 0.08 to 0.21 kg) and for LBE of 0.21 ± 0.03 kg ($CI95\%_{diff}$ = 0.14 to 0.28 kg) (Table 1, Figure 1).

Reliability estimates

The consistency of the body composition scores as computed by the CV (%) was high across experimental conditions (inconsistency is determined when CV ≥ 10%) (Currell & Jeukendrup, 2008). For the NEC condition, the absolute reliability was high for the arms region (Min = 1.90, Max = 3.50%), the legs region (Min = 1.17, Max = 2.50%), and total body (Min = 0.22, Max = 1.64%). For the UBE condition, the absolute reliability was high for the arms region (Min = 1.85%, Max = 3.85%), and the legs region (Min = 1.13%, Max = 2.37%); however, for the total body the reliability scores were mostly high (Min = 0.17%, Max = 3.65%), with only one score > 10% (i.e., fat mass in kg = 15.97%). Finally, for the LBE condition, the reliability was high for the arms region (Min = 2.00%, Max = 3.76%), for the total body (Min = 0.24%, Max = 6.31%), and mostly for the legs region (Min = 1.16%, Max = 2.33%), with only one score > 10% (i.e., fat mass in kg = 13.89%) (Table 3).

Regardless of the experimental condition, the relative (i.e., %) SWC for tissue fat and region fat for the arms, legs, and total body was between 0.13% and 0.22%. Also, regardless of the experimental condition, the SWC in kg for tissue, fat mass, lean mass, BMC, and total mass was between 0.00 kg and 0.86 kg (Table 3).

DISCUSSION

The study aimed to determine changes in DXA body composition scores in females following exercise-induced body fluid redistribution. We predicted changes in body composition scores following acute exercise, and our main findings were that

body composition scores acutely changed following the three experimental conditions; the scores were highly reliable, and the SWC was small for each outcome.

We did not expect body composition scores changes following the seated NEC, yet the small change was detected by the DXA device, a value that reached the expected SWC. We expected relevant changes in body composition scores only following the two exercise experimental conditions (i.e., UBE, LBE) since working muscles redistribute more body fluids than a seated NEC. Indeed, both exercise conditions elicited significantly higher fluid losses (i.e., UBE ~143 g, LBE ~206 g), as determined by the change in total body mass following the respective experimental condition, compared to NEC (~50 g). The changes in body mass were explained by losses in body water occurring by the sweating response elicited to control the increased body temperature resulting from the intense muscle work (~70% HRR) during exercise (Périard et al., 2021; Trangmar & González-Alonso, 2019). Thus, an increased sweat production implies body fluid redistribution occurred during the exercise conditions to maintain the heat balance.

In the present study, we found that brief acute exercise (30-min) did not immediately affect BMC. This is because bones respond more to long-term, chronic mechanical loading rather than acute stressors. It takes weeks to months for actual mineralization of bone to become evident through changes in BMC (Gillies & Lieber, 2011). Additionally, changes in bone turnover markers induced by acute exercise may not be large enough to result in detectable alterations in BMC in the short term (Kohrt et al., 2004). In our study, we aimed to detect changes in highly dependent body fluid tissues (i.e., muscle mass) and their possible influence on DXA body composition scores. As such, BMC was not expected to change beyond measurement error.

In the present study, we reported the TEM since it assumes that errors occur from random events instead of a systematic error (i.e., biological variation) when measuring body composition variables (Adão Perini et al., 2005; Lucas & Henneberg, 2017). The arms region analyses showed significant mean differences in selected body composition outcomes; some changes were smaller than the estimated TEM (Table 3). For example, the TEM for fat tissue (%) was higher than the observed mean difference in the NEC and UBE experimental conditions. Also, the TEM was higher for the fat region (%) than the observed mean difference in the NEC and UBE experimental conditions. On the contrary, the TEM was smaller than the observed mean differences in the UBE experimental condition for tissue, lean mass, and total mass. The legs region analyses also showed significant mean differences in the UBE experimental condition smaller than the TEM for tissue fat and region fat but for lean mass, which was higher than the TEM. Finally, the total body region analyses showed significant mean differences in the UBE and LEB experimental conditions on tissue and total mass higher than the TEM. From a practical perspective, the TEM can be quantified and controlled with proper instructions to the individual being assessed and by careful positioning in the DXA by the responsible technician. For instance, in the present study, two researchers responsible for the DXA assessments underwent a precision study, and their computed coefficients of variation were below 0.4% for body composition variables, a precision error judged acceptable by the International Society for Clinical Densitometry (2019). Nevertheless, the random error affecting TEM will always be present.

Taken together, the present study's findings suggest that, as opposed to LBE, UBE exerted a meaningful impact on selected body composition scores following exercise. Likely, the increased metabolic demand of the small muscles of the forearm (primarily responsible for the UBE experimental condition) caused a hyperemic transient state that might have remained during the post-DXA scan assessment (Dulaney et al., 2023; Joyner & Casey, 2015). Consequently, the DXA software detected changes in some body composition outcomes. The precise interaction between software programming (i.e., X-ray attenuation) and true physiological changes resulting from exercise and the impact on body composition scores deserves further examination. Therefore, from a practical point of view, it is recommended that individuals undergoing DXA assessment avoid engaging in acute exercise at least 30-min prior to the measurement session. This can minimize any noise during scanning and ensure accurate results.

High reliability was found in the DXA body composition scores in the three experimental conditions. Only one score in the UBE and LBE experimental conditions was moderate (i.e., CV ≥ 10%). Our results are similar to those reported by others (Rose et al., 2021), with CV (%) smaller than 2% for lean mass and 3% for fat mass; precision figures accepted by the International Society for Clinical Densitometry (2019). The SWC calculated for all body composition variables was small in relative and absolute units, which may be explained by the low variability of scores (i.e., TEM) (Hopkins, 2000). Therefore, in the present study, the values recorded were within the expected range, giving technicians the confidence that they were accurate, regardless of the experimental condition. However, it is essential to note that reaching the SWC is necessary to determine any meaningful changes in body composition scores; and in this particular study, the recorded values remained stable.

Study strengths and limitations

This study has strengths and limitations. First, we used a repeated measures design where all participants completed the experimental sessions; therefore, we reduced between-subject variability. Secondly, we performed a successful precision study as the International Society for Clinical Densitometry (2019) recommended. Third, we assessed initial hydration status and provided instructions to reduce physical activity the day before testing occurred. Potential limitations included the lack of control of the participant's diet (i.e., food and fluid intake); however, the potential influence of diet was controlled by the random assignment of the participants to the experimental conditions and by requiring participants to arrive to the assessment sessions in a 10-h fasting state. In addition, we could not assess total body water immediately following the experimental conditions since DXA assessment was our priority, and fluid redistribution might have caused bias in BIA measures. Finally, we did not collect information on the individuals' menstrual cycle. However, experimental and meta-analytical evidence (Gould et al., 2021) indicates that DXA body composition scores are not affected beyond measurement error as a result of compartmental changes elicited by the menstrual cycle. Furthermore, we only performed DXA scans on euhydrated individuals. Thus, despite not controlling the menstrual cycle, no differences in weight loss elicited by sweat evaporation from the thermoregulatory response were expected.

CONCLUSION

This study found that exercise-induced body fluid redistribution in young college females elicited small changes in body composition scores. Small changes can be considered practically and clinically meaningless. Most small changes were observed following the UBE experimental condition and might have resulted from transient hyperemia in the forearm muscles, which might have impacted DXA's X-ray attenuation. The majority of body composition scores recorded were reliable in the three experimental conditions, and the SWC reported were small due to the low TEM. Therefore, to reduce random variation and record accurate scores, DXA technicians should control the previous physical activity of participants undergoing DXA scanning.

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REFERENCES

Adão Perini, T., Lameira de Oliveira, G., dos Santos Ornellas, J., & Palha de Oliveira, F. (2005). Technical error of measurement in anthropometry. *Revista Brasileira de Medicina do Esporte*, *11*(1), 81–85.

Armstrong, L. E. (2007). Assessing hydration status: the elusive gold standard. *J. Am. Coll. Nutr.*, *26*(5 Suppl.), 575S–584S.

Calbet, J. A., Dorado, C., Diaz-Herrera, P., & Rodriguez-Rodriguez, L. P. (2001). High femoral bone mineral content and density in male football (soccer) players. *Med. Sci. Sports Exerc.*, *33*(10), 1682–1687. http://www.ncbi.nlm.nih.gov/pubmed/11581552.

Chacón-Araya, Y., Carpio-Rivera, E., Quirós-Quirós, A., & Moncada-Jiménez, J. (2024). The Effect of a Compression Bandage on Dual Energy X-ray Absorptiometry Body Composition Scores. *J. Clin. Densitom.*, *27*(1), 101461. https://doi.org/10.1016/j.jocd.2023.101461.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Currell, K., & Jeukendrup, A. E. (2008). Validity, Reliability and Sensitivity of Measures of Sporting Performance. *Sports Med.*, *38*(4), 297–316.

Dulaney, C. S., Heidorn, C. E., Singer, T. J., & McDaniel, J. (2023). Mechanisms that underlie blood flow regulation at rest and during exercise. *Adv. Physiol. Educ.*, *47*(1), 26–36. https://doi.org/10.1152/advan.00180.2022.

Formica, C., Atkinson, M. G., Nyulasi, I., McKay, J., Heale, W., & Seeman, E. (1993). Body composition following hemodialysis: studies using dual-energy X-ray absorptiometry and bioelectrical impedance analysis. *Osteoporos. Int.*, *3*(4), 192–197.

Fosbøl, M. Ø., & Zerahn, B. (2015). Contemporary methods of body composition measurement. *Clin. Physiol. Funct. Imaging*, *35*(2), 81–97. https://doi.org/10.1111/cpf.12152.

Gillies, A. R., & Lieber, R. L. (2011). Structure and function of the skeletal muscle extracellular matrix. *Muscle & Nerve*, *44*(3), 318–331. https://doi.org/10.1002/mus.22094.

Gould, L. M., Cabre, H. E., Brewer, G. J., Hirsch, K. R., Blue, M. N. M., & Smith-Ryan, A. E. (2021). Impact of Follicular Menstrual Phase on Body Composition Measures and Resting Metabolism. *Med. Sci. Sports Exerc.*, *53*(11), 2396–2404. https://doi.org/10.1249/mss.0000000000002702.

Hopkins, W. G. (2000). Measures of Reliability in Sports Medicine and Science. *Sports Medicine*, *30*(1), 1–15. https://doi.org/10.2165/00007256-200030010-00001.

Hume, P. A., Kerr, D. A., & Ackland, T. R. (2018). *Best Practice Protocols for Physique Assessment in Sport*. Singapore: Springer, 276 p.

International Society for Clinical Densitometry (2019). *Official Positions of the International Society for Clinical Densitometry*. https://iscd.org/wp-content/uploads/2021/09/2019-Official-Positions-Adult-1.pdf.

Joyner, M. J., & Casey, D. P. (2015). Regulation of increased blood flow (hyperemia) to muscles during exercise: a hierarchy of competing physiological needs. *Physiol. Rev.*, *95*(2), 549–601. https://doi.org/10.1152/physrev.00035.2013.

Karahan, A. Y., Kaya, B., Kuran, B., Altindag, O., Yildirim, P., Dogan, S. C., Basaran, A., Salbas, E., Altinbilek, T., Guler, T., Tolu, S., Hasbek, Z., Ordahan, B., Kaydok, E., Yucel, U., Yesilyurt, S., Polat, A. D., Cubukcu, M., Nas, O., ... Karpuz, S. (2016). Common Mistakes in the Dual-Energy X-ray Absorptiometry (DXA) in Turkey. A Retrospective Descriptive Multicenter Study. *Acta Medica* (*Hradec Kralove*), *59*(4), 117–123. https://doi.org/10.14712/18059694.2017.38.

Kerr, A., Slater, G. J., & Byrne, N. (2017). Impact of food and fluid intake on technical and biological measurement error in body composition assessment methods in athletes. *Br. J. Nutr.*, *117*(4), 591–601. https://doi.org/10.1017/s0007114517000551.

Kohrt, W. M., Bloomfield, S. A., Little, K. D., Nelson, M. E., & Yingling, V. R. (2004). American College of Sports Medicine Position Stand: physical activity and bone health. *Medicine and Science in Sports and Exercise*, *36*(11), 1985–1996. https://doi.org/10.1249/01.mss.0000142662.21767.58.

LaForgia, J., Dollman, J., Dale, M. J., Withers, R. T., & Hill, A. M. (2009). Validation of DXA body composition estimates in obese men and women. *Obesity* (*Silver Spring*), *17*(4), 821–826. https://doi.org/10.1038/oby.2008.595.

Lewiecki, E. M., Binkley, N., Morgan, S. L., Shuhart, C. R., Camargos, B. M., Carey, J. J., Gordon, C. M., Jankowski, L. G., Lee, J.-K., & Leslie, W. D. (2016). Best Practices for Dual-Energy X-ray Absorptiometry Measurement and Reporting: International Society for Clinical Densitometry Guidance. *Journal of Clinical Densitometry*, *19*(2), 127–140. https://doi.org/10.1016/j.jocd.2016.03.003.

Lucas, T., & Henneberg, M. (2017). Use of units of measurement error in anthropometric comparisons. *Anthropol. Anz.*, *74*(3), 183–192. https://doi.org/10.1127/anthranz/2017/0628.

McNamara, E. A., Feldman, A. Z., Malabanan, A. O., Abate, E. G., Whittaker, L. G., Yano-Litwin, A., Dorazio, J., & Rosen, H. N. (2015). Effect of Clothing on Measurement of Bone Mineral Density. *Journal of Clinical Densitometry*, *19*(2), 216–219. https://doi.org/https://doi.org/10.1016/j.jocd.2015.05.071.

Messina, C., Albano, D., Gitto, S., Tofanelli, L., Bazzocchi, A., Ulivieri, F. M., Guglielmi, G., & Sconfienza, L. M. (2020). Body composition with dual energy X-ray absorptiometry: from basics to new tools. *Quant. Imaging Med. Surg.*, *10*(8), 1687–1698. https://doi.org/10.21037/qims.2020.03.02.

Messina, C., Bandirali, M., Sconfienza, L. M., D'Alonzo, N. K., Di Leo, G., Papini, G. D., Ulivieri, F. M., & Sardanelli, F. (2015). Prevalence and type of errors in dual-energy x-ray absorptiometry. *Eur. Radiol.*, *25*(5), 1504–1511. https://doi.org/10.1007/s00330-014-3509-y.

Nana, A., Slater, G. J., Hopkins, W. G., & Burke, L. M. (2013). Effects of exercise sessions on DXA measurements of body composition in active people. *Med. Sci. Sports Exerc.*, *45*(1), 178–185. https://doi.org/10.1249/MSS.0b013e31826c9cfd.

Nana, A., Slater, G. J., Stewart, A. D., & Burke, L. M. (2015). Methodology review: using dual-energy X-ray absorptiometry (DXA) for the assessment of body composition in athletes and active people. *Int. J. Sport Nutr. Exerc. Metab.*, *25*(2), 198–215. https://doi.org/10.1123/ijsnem.2013-0228.

Oppliger, R. A., Magnes, S. A., Popowski, L. A., & Gisolfi, C. V. (2005). Accuracy of urine specific gravity and osmolality as indicators of hydration status. *Int. J. Sport Nutr. Exerc. Metab.*, *15*(3), 236–251.

Périard, J. D., Eijsvogels, T. M. H., & Daanen, H. A. M. (2021). Exercise under heat stress: thermoregulation, hydration, performance implications, and mitigation strategies. *Physiol. Rev.*, *101*(4), 1873–1979. https://doi.org/10.1152/physrev.00038.2020.

Pietrobelli, A., Wang, Z., Formica, C., & Heymsfield, S. B. (1998). Dual-energy X-ray absorptiometry: fat estimation errors due to variation in soft tissue hydration. *Am. J. Physiol.*, *274*(5 Pt 1), E808–816.

Rose, G. L., Farley, M. J., Slater, G. J., Ward, L. C., Skinner, T. L., Keating, S. E., & Schaumberg, M. A. (2021). How body composition techniques measure up for reliability across the age-span. *Am. J. Clin. Nutr.*, *114*(1), 281–294. https://doi.org/10.1093/ajcn/nqab046.

Tanaka, H., Monahan, K. D., & Seals, D. R. (2001). Age-predicted maximal heart rate revisited. *J. Am. Coll. Cardiol.*, *37*(1), 153–156. https://doi.org/https://doi.org/10.1016/S0735-1097(00)01054-8.

Thurlow, S., Oldroyd, B., & Hind, K. (2018). Effect of Hand Positioning on DXA Total and Regional Bone and Body Composition Parameters, Precision Error, and Least Significant Change. *Journal of Clinical Densitometry*, *21*(3), 375–382. https://doi.org/10.1016/j.jocd.2017.03.003.

Toomey, C. M., McCormack, W. G., & Jakeman, P. (2017). The effect of hydration status on the measurement of lean tissue mass by dual-energy X-ray absorptiometry. *Eur. J. Appl. Physiol.*, *117*(3), 567–574. https://doi.org/10.1007/s00421-017-3552-x.

Trangmar, S. J., & González-Alonso, J. (2019). Heat, Hydration and the Human Brain, Heart and Skeletal Muscles. *Sports Med.*, *49*(Suppl. 1), 69–85. https://doi.org/10.1007/s40279-018-1033-y.

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