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Original Research

Dosage of Physical Activity to Avoid Impairment of Activities Due to Pain: Analysis of Population-based Conditional Processes

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ABSTRACT

Background: Physical activity's established health benefits include pain control, yet there is no consensus on the required dosage according to the literature.
Aim: To test the influence of exercise on perceived health in patients whose daily activities are limited due to pain. Besides, analyze the possible moderating effect of age and find a formula for exercise dosage based on the perceived level of health.
Methods: Cross-sectional study based on the 2017 Spanish National Health Survey with 4,123 participants reporting activity limitations in their daily activities due to pain. The International Physical Activity Questionnaire (short version) was used to calculate energy expenditure. Data included age, sex, leisure-time physical activity, sitting time, pain-related impairments, pain medication, and perceived health. Mediation regression analysis was conducted using the SPSS PROCESS 4.0 macro.
Results: Results indicate a decline in perceived health with age. The relationship between exercise (energy expenditure) and perceived health was highly significant (d=-0.224, $p<0.001$). Age moderated the association between pain and energy expenditure up to 75.61 years (0.1568, $p=0.05$) and between energy expenditure and perceived health up to 75.74 years (-0.289, $p=0.05$), but this effect diminished afterwards. A formula was developed to estimate energy expenditure based on the desired level of health.
Conclusions: The perception of health in people who are limited in their daily activities due to pain (moderate to very much) is mediated by the amount of physical activity they perform. Besides, this perception is moderated by age, up to 76 years.

Since British epidemiologist, Morris et al. (1953), discovered in the 1950s that London bus drivers were more at risk of cardiovascular disease because they sat all day than bus conductors, who were constantly on the move, studies promulgating the beneficial effects of physical activity on health have been growing steadily to the point where it could be argued that physical activity saves lives (Saint-Maurice et al., 2022).

Nevertheless, the beneficial effects of physical exercise on health can be approached from more specific perspectives, such as, for example, that of pain. It is estimated that in Spain, chronic pain affects approximately 18% of the population (one point below the European average), with a moderate to severe intensity in 12% of cases (Caramés-Álvarez & Navarro-Ribero, 2016). This matter represents an economic cost of approximately 2.5% of the Gross Domestic Product (Torralba et al., 2014). This economic cost is

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related to the severity of the problem and is used as a point of comparison to other health problems and conditions. Therefore, therapeutic approaches, such as exercise, can help alleviate patients and health resources.

Naugle et al. (2012), concluded that exercise decreased experimentally induced pain moderately to highly but could not determine the optimal dose. A systematic review and meta-analysis by Booth et al. (2017) also highlighted the usefulness of exercise in managing chronic musculoskeletal pain using a biopsychosocial approach and the difficulty of dosing. Somewhat later, in 2019, another systematic review and meta-analysis of observational studies by Alzahrani et al. (2019) evidenced that the effect of aerobic exercise on chronic musculoskeletal pain was uncertain regarding the best way to prescribe exercise. In the same year, Polaski et al. (2019), aware of the problem of the ideal dose, carried out a meta-analysis that revealed a positive correlation, although of moderate effect, between an increase in exercise sessions and neck pain. However, they pointed out the importance of describing the exercise dose by specifying the type of exercise, frequency, duration, and intensity. Furthermore, Takahara-Yamauchi et al. (2021), in an experimental study on rats, provided evidence of the analgesic effect of exercise on persistent inflammatory pain. Finally, in 2021, three systematic reviews and meta-analyses corroborated these findings: Belavy et al. (2021) selected studies using only quantitative sensory tests and concluded that exercise reduced chronic pain. García-Correa et al. (2021) evidenced that aerobic exercise improved the quality of life in patients with chronic pain. Frutiger & Borotkanics (2021) found that neck strengthening exercises and workplace modifications reduced neck pain in office workers. The evidence was low to moderate in all of these, and the need to specify dosage was expected. They also demonstrated the necessity to identify mechanisms of action.

A simple tool for collecting exercise dosage data is the International Physical Activity Questionnaire (IPAQ), whose short version, adapted to the Spanish population, has shown good psychometric properties (Mantilla-Toloza & Gómez-Conesa, 2007; Pérez-Soto & García-Cantó, 2012). The questionnaire collects data on exercise type, frequency, duration and intensity, and sedentary time, the final expression of which can be quantified in metabolic equivalents (METs). One MET is the energy (measured in the amount of oxygen consumed) individuals spend when resting or sitting still (Jetté et al. 1990; World Confederation for Physical Therapy, 2020).

Mechanisms of action, where activation of the mesocorticolimbic system may explain the mechanism underlying chronic pain relief, also include psychosocial factors. For example, adverse family environments and mood may affect both sensitivity and the ability to modulate exercise-induced hypoalgesia (Kami et al., 2022). Thus, how we perceive our health or the extent to which pain affects us are variables to be assessed.

Perceived or self-perceived health, defined as our perception of our general health status, is a good approximation of the overall health status of individuals despite its simplicity, subjectivity, and multidimensionality (Valencia International University, 2017). Among various factors that affect the perception of health, some are more quantifiable, such as age. However, others are complex in themselves, such as pain. Nevertheless, measuring how pain affects the performance of daily activities (usual and leisure) is one of the purposes of the SF-36v2 health questionnaire, one of the most widely used and evaluated health-related quality of life instruments. Daily activities encompass tasks that comprise everyday living, such as feeding, sitting and getting up, dressing and undressing, showering or bathing, preparing meals, etc. Additionally, the SF-36v2 has been widely validated for the Spanish population (Vilagut et al., 2005) and was included in the National Health Survey 2017 (ENSE 2017).

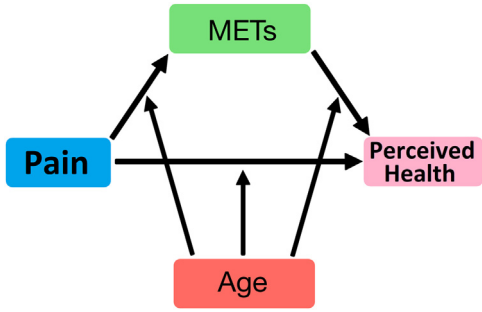


Figure 1. Proposed model. METs = Metabolic Equivalents; Pain = limitation of daily activities due to pain.

The perception of health is affected by multiple factors and we hypothesize that the limitation of daily activities due to pain is one of them. However, the amount of exercise of task (METs) and, consequently, energy expenditure, will mediate the relationship so that more METs are associated with a better perception of health. Nevertheless, age is a variable that may moderate the relationships between all the variables. For this reason, it could be altering the relationship between limitation of daily activities due to pain and METs by causing less exercise to be performed when there is more pain. It could be altering the relationship between METs and perception of health, causing the increase or decrease in METs to modify how health is perceived. Moreover, it could vary the relationship between limitation of daily activities due to pain and perception of health because age is associated with more pain and worse perception of health (Fig. 1).

Therefore, we tested whether limitation of daily activities due to pain influences perception of health and if METS mediate the relationship; furthermore, we tested if age moderates the relationships between limitation of daily activities due to pain and METs, limitation of daily activities due to pain and perception of health, and limitation of daily activities due to pain and METs. Finally, we set out to find a formula expressing the relationship of METs and perception of health for cases of confirmation. Although many aspects of pain depend on nursing, previous studies have pointed out that the level of knowledge on this topic is inadequate among nurses (Al-Atiyyat et al., 2019; Alnajar et al., 2019; Latina et al., 2015; Utne et al., 2019). For this reason, this formula could be helpful in these professionals' daily approach to pain and enable them to prescribe appropriate physical activity and increase perceived levels of health.

Methods

Population and Sample

A cross-sectional population-based study has been designed based on the ENSE 2017 (Ministerio de Sanidad, Consumo y Bienestar Social, 2017), a National Health Survey carried out by the Ministry of Health, Consumer Affairs, and Social Welfare with the collaboration of the National Statistics Institute. The ENSE has been conducted every five years since 1987 and collects health information on the resident population in Spain. The survey consists of three questionnaires: household, adult, and underage. The information collection method in the adult questionnaire is direct computer-assisted personal interview. The questionnaire consists of four main blocks: socio-demographic, health status, health care, and health determinants.

Stratified three-stage sampling was carried out, distributing the sample of 23,860 households among the Autonomous Communities uniformly and proportionally to their size. Likewise, the census sections were selected within each stratum with probability proportional to their size. The dwellings were extracted through systematic sampling after sorting by size in each section, which led to self-weighted samples in each stratum. The Kish random procedure, which assigns equal probability to all household components, was used to select individuals.

From a sample of 29,800 people, 4,123 subjects were selected who reported being limited in their daily activities by pain (categories are moderate, quite a lot, and very much). Cases that selected the categories no limitation or a little limitation were excluded. We also excluded "do not know" or "no answer" responses for any of the variables analyzed and values that did not belong to any items included in the scales.

Variables and measurement

a. Age (years).
b. Sex.
c. Leisure-time physical activity [LTPA] (none, occasional, several times a month, several times a week).
d. Sitting time (in minutes).
e. Impairment limitation of daily activities due to pain (moderately, quite a lot, very much).
f. Pain medicines (yes, no).
g. Perceived health (very good, good, fair, bad, very bad).

Procedure

Physical activity data, obtained through the short version of the IPAQ and included in the ENSE 2017, were used to calculate energy expenditure in metabolic equivalents (METs).

The mean energy expenditure and 95% confidence interval (CI) were calculated for each perception of health variable category. Then, the values obtained for each category ("Very bad" and "Bad" were unified, as they had the same mean value) were joined using polynomial trend lines, and their equations were calculated using Microsoft Excel.

Ethical and legal aspects

The use of ENSE data does not require approval by an ethics committee. Furthermore, according to Regulation (EU) 2016/679 (Ministerio de Sanidad, Consumo y Bienestar Social, 2017), files for public use are not considered confidential. Finally, the national health survey makes anonymized microdata files available to the public, making it impossible to identify the respondent directly or indirectly.

Statistical analysis

IBM SPSS Statistics 26.0 software (IBM, Chicago, IL, USA) was used for statistical analysis. Quantitative variables were represented by arithmetic mean, 95% CI, and standard deviation, while qualitative variables were summarized according to their absolute frequencies and percentages. Normality was assessed using the Kolmogorov-Smirnov test with Lilliefors correction.

For the analysis of contingency tables with dichotomous and nominal polytomous variables, the Chi-square test was used. For dichotomous and quantitative variables, the Mann-Whitney U test was used. Finally, for the single-factor analysis with ordinal variables, treated as dependent, quantitative, ordinal, and dichotomous variables, Spearman's Rho test (or Kendall's Tau-b test, if the relationship was not monotonic), Sommers' D test, and ordinal regression were applied, respectively.

A mediation regression analysis was performed using SPSS PROCESS 4.0 macro. Model 4 was used for the simple mediation analysis and model 59 for the moderated mediation analysis, both with 95% CIs and 10,000 bootstrapping samples. The Johnson-Neyman method was selected to identify and represent areas of significance.

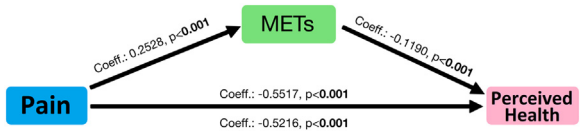


Figure 2. Statistical diagram of simple mediation analysis. METs = Metabolic Equivalents; Pain = limitation of daily activities due to pain.

Results

Description of the Sample

Table 1 shows the variables analyzed in total numbers and according to sex, where significant and highly significant relationships stand out for all variables except perception of health. For example, higher percentages are observed in limitation of daily activities due to pain and taking pain medication among women and lower energy expenditure. Furthermore, a lower amount of time spent sitting down was found in this group.

Single factor analysis

Table 2 shows the results of the inferential analysis between perception of health and the rest of the variables, where all the relationships are highly significant. In general, health is perceived to be worse as age increases and when limitation of daily activities due to pain goes from moderate to very much. Concerning LTPA-METs, higher energy expenditure and better health perception are observed and vice versa. However, the mean sitting time was higher in the categories with the best health perception (very good and good). No differences were found between taking medicines and total energy expenditure ($p = .268$) and sedentary time ($p = .088$). The relationship between LTPA-METs and perceived health was highly significant ($d = -0.224$, $p < .001$), and this was maintained when the differential relationship was studied for taking pain medication ($d = -0.227$, $p < .001$) or not taking pain medication ($d = -0.213$, $p < .001$) (Table 2).

Simple mediation analysis

Figure 2 shows the statistical plot of the simple mediation model where it can be observed that all coefficients reached high significance.

Moderate mediation analysis

Figure 3 shows the statistical plot of the moderated mediation model where significant and highly significant values stand out for all coefficients except for the relationship between limitation of daily activities due to pain and perception of health ($c'1 = -0.1677$, $p = .2006$).

The Johnson-Neyman method showed that the moderating effect of age between limitation of daily activities due to pain and METs was significant up to 75.61 years (0.1568, $p = .05$). Furthermore, the association between METs and perception of health was significant up to 75.74 years (–0.289, $p = .05$) but lost after that (Fig. 3).

Calculation of energy expenditure as a function of perceived health status

Figure 4 shows the mean values and 95% CIs of the METS, according to perception of health categories, where it is

Table 1
Total Values and Sex Differences (N = 4123)

		Total (N=4123)	Man (n=1385)	Woman (n=2738)	*p* value
Age (SD)		62.58 (17.33)	61.17 (16,69)	63,29 (17.60)	<.001
Perceived Health	Very good	96 (2.3%)	33 (2.4%)	63 (2.3%)	.909
	Good	860 (20.9%)	298 (21.5%)	562 (20.5%)	
	Fair	1853 (44.9%)	614 (44.3%)	1239 (45.3%)	
	Bad	987 (23.9%)	335 (24.2%)	652 (23.8%)	
	Very bad	327 (7.9%)	105 (7.6%)	222 (8.1%)	
Impairment of activities due to pain	Moderately	2137 (51.8%)	758 (54.7%)	1379 (50.4%)	.019
	Quite a lot	1332 (32.3%)	411 (29.7%)	921 (33.6%)	
	Very much	654 (15.9%	216 (15.6%)	438 (16%)	
Pain medicines	Yes	3295 (79.9%)	1012 (73.1%)	2283 (83.4%)	<.001
	No	828 (20.1%)	373 (26.9%)	455 (16.6%)	
LTPA METs	<333	2457 (59.6%)	813 (58.7%)	1644 (60%)	.004
	333 - 667	279 (6.8%)	93 (6.7%)	186 (6.8%)	
	668 - 1096	318 (7.7%)	84 (3.1%)	234 (8.5%)	
	1097 - 1739	415 (10.1%)	140 (10.1%)	275 (10%)	
	1740 - 2697	203 (4.9%)	73 (5.3%)	130 (4.7%)	
	>2697	451 (10.9%)	182 (13.1%)	269 (9.8%)	
Total METs (95%IC)		995.49 (924.445-1066.54)	1144.97 (1006.93-1283.01)	921.81 (840.93-1002.69)	.042
Sitting time in minutes (95%CI)		186.4 (180.14-192.66)	212.70 (201.23-224.17)	173.53 (166.14-180.91)	<.001

CI = confidence interval; LTPA = leisure-time physical activity; METs = metabolic equivalents; SD = standard deviation.

Table 2
Relationship Between Perceived Health and Other Variables (N = 4123)

		Perceived Health					
		Very good	Good	Fair	Bad	Very bad	*p* value
Age (SD)		45.73 (19.75)	56.95 (18.58)	63.46 (16.74)	66.34 (15.40)	65.94 (15.43)	<.001
Impairment of activities due to pain	Moderately	64 (3%)	534 (25%)	1085 (50.8%)	382 (17.9%)	72 (3.4%)	<.001
	Quite a lot	24 (1.8%)	238 (17.9%)	568 (42.6%)	390 (29.3%)	112 (8.4%)	
	Very much	8 (1.2%)	88 (13.5%)	200 (30.6%)	215 (32.9%)	143 (21.9%)	
Pain medicines	Yes	69 (2.1%)	628 (19.1%)	1484 (45%)	837 (25.4%)	277 (8.4%)	<.001
	No	27 (3.3%)	232 (28%)	369 (44.6%)	150 (18.1%)	50 (6%)	
LTPA METs	<333	28 (1.1%)	384 (15.7%)	1087 (44.2%)	708 (28.8%)	250 (10.2%)	<.001
	333 - 667	7 (2.5%)	60 (21.5%)	138 (49.5%)	58 (20.8%)	16 (5.7%)	
	668 - 1096	6 (1.9%)	73 (23%)	154 (48.4%)	68 (21.4%)	17 (5.3%)	
	1097 - 1739	13 (3.1%)	117 (28.2%)	193 (46.5%)	72 (17.3%)	20 (4.8%)	
	1740 - 2697	13 (6.4%)	72 (35.5%)	79 (38.9%)	34 (16.7%)	5 (2.5%)	
	>2697	29 (6.4%)	154 (34.1%)	202 (44.8%)	47 (10.4%)	19 (4.2%)	
Total METs (95%CI)		2143.83 (1589.81-2697.84)	1551.81 (1364.29-1739.33)	994.04 (891.15-1096.93)	549.67 (432.20-667.14)	549.18 (333.60-764.76)	<.001
Sitting time in minutes (95%CI)		251.56 (212.78-290.34)	217.72 (204.21-231.22)	169.25 (160.67-177.82)	180.68 (166.86-194.51)	199.40 (173.11-225.70)	<.001

CI = confidence interval; LTPA = leisure-time physical activity; METs = metabolic equivalents; SD = standard deviation.

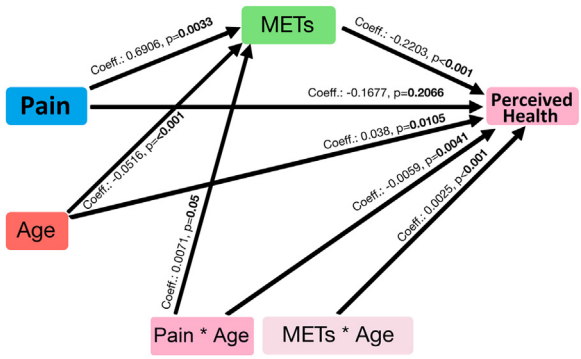
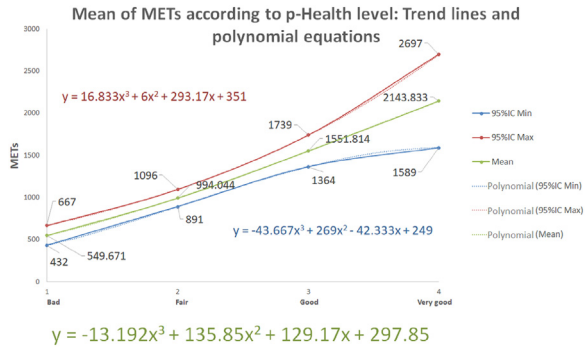


Figure 3. Statistical diagram of conditional process analysis. METs = Metabolic Equivalents; Pain = limitation of daily activities due to pain.



y = -13.192x³ + 135.85x² + 129.17x + 297.85

Figure 4. Mean of METs according to Perceived Health level: Trend lines and polynomial equations. IC = Confidence Interval; METs = Metabolic Equivalents; p-Health: Perception of Health.

evidenced that perception of health boosts as energy expenditure increases.

The polynomial equation of the mean, $y = -13.192x^3 + 135.85x^2 + 129.17x + 297.85$, allows the METs to be calculated according to the level of perception of health to be reached. The equations of the CIs can also be found in Figure 4.

Discussion

A population-based study has been developed to analyze the mediating effect of LTPA (measured in METs) between limitation of daily activities due to pain and perception of health. In addition,

the moderating effect of age has been studied among all of the above. Furthermore, a formula expressing the relationship between METs and perception of health has been identified. The results confirm the mediating effect of METs between limitation of daily activities due to pain and perception of health and the moderating effect of age between them.

It is striking to note significant and highly significant differences between men and women for all the variables analyzed except for perception of health. These results contrast to what was stated by the Indicators of Health Status in Spain 2017, which stressed that women live longer than men but perceive their health to be worse (Ministerio de Sanidad & Servicios Sociales e Igualdad, 2017). The age range of our population could explain our differences because we have selected those who reported some pain that limited their activities. Another reason could be due to not differentiating by educational levels or employment status, factors whose influence on the perception of health according to sex has been highlighted in other studies (Chavarrías-Hernández, 2020; Sánchez-Cruz et al., 2017).

The higher consumption of pain medication, lower energy expenditure, and less time spent sitting down are differences explained by the higher prevalence of chronic problems among women and the greater dedication to domestic work (Gil-García & Cáceres Matos, 2020; Morcillo-Cebolla, 2017).

As for the relationship between the perception of health categories and the rest of the variables, the high significance is consistent with what is expected. That is, perception of health worsens as we get older or as pain increases. We have also found that perception of health improves as the energy expenditure for LTPA increases. However, this relationship could be interpreted in both directions (i.e., that we perform more exercise because we feel better). However, not all people who feel good perform physical activities if they have not acquired this habit. Furthermore, several studies highlight the deleterious effects of physical inactivity, which promotes chronic systemic inflammation and alteration of lipid and glycaemic metabolism and causes pathologies associated with lack of activity (Pérez-López et al., 2017). These individuals would then fall into a cycle where they would feel worse and worse and therefore be less willing to exercise.

Also underlined is the high significance found between perception of health and sitting time. We can observe higher mean values for the categories "Very Good" and "Good" and lower (although increasing) values for the categories "Fair", "Bad", and "Very Bad". The age distribution could be behind these results because we found more sedentary time in younger people (between 45 and 57 years) who may experience more sedentary time for work and leisure (Hadgraft et al., 2015). Although the difference was highly significant, the value reached was low ($\tau = -0.0074$).

One of the main questions we asked was whether taking painkillers modified sedentary time. Not taking them could be increasing this time to avoid the pain associated with performing daily activities. Alternatively, taking them might decrease it by facilitating exercise. However, we found that the distribution of METs was the same between those who took painkillers and those who did not, and the sedentary time was the same. These results suggest that taking painkillers is not a sufficient reason to change exercise or sedentary habits and that exercise itself offers an analgesic effect (Henriksen et al., 2016), likely based on endogenous opioid mechanisms (Bruehl et al., 2020; Bruehl et al. 2021). Results also suggest that a poorer perception of health is related to lower energy expenditure through physical activity. In addition, since low-income levels are associated with less exercise and more consumption of analgesics, it is important to highlight that we have not assessed the economic level of the sample (Turner et al., 2017) and, of course, the multifactorial nature of pain.

The mediating character of METs between limitation of daily activities due to pain and perception of health was confirmed by simple mediation analysis to answer our first hypothesis (Fig. 2). The coefficients a, b, c, and c' are highly significant. The value of limitation of daily activities due to pain is dichotomized into –0.5 ("Very much") and +0.5 ("Moderately" to "Quite a lot"), and the sign of the relationship with the other variables explains its significance. The negative values of coefficient b (association between METs and perception of health) and the coefficients c and c' (association between limitation of daily activities due to pain and perception of health) imply inverse relationships. That is, the fewer METs, the worse perception of health and the more limitation of daily activities due to pain, the worse perception of health. On the other hand, coefficient a's positive value implies that when going from limitation of daily activities due to pain "Very Much" to limitation of daily activities due to pain "Moderately" to "Quite a lot", the METs increase. In summary, the direct effect of the variable limitation of daily activities due to pain on perception of health decreases for the total effect due to the mediating effect of METs (coeff. c' = –0.5216 and coeff. c = –0.5517). In other words, energy expenditure by physical activity mediates the relationship between limitation of daily activities due to pain and perception of health in that higher expenditure means better-perceived health for those whose activities are limited by pain, as other studies have shown (Zhang et al., 2022).

The question of whether age had a moderating effect on the variables analyzed is answered through the moderated mediation analysis (Fig. 3). In all the relationships, age acts as a moderating variable, with the mediating effects of METs on limitation of daily activities due to pain on perception of health remaining (in fact, the coefficients increase) but disappearing the direct effect. That is, the effect of limitation of daily activities due to pain on perception of health is lost except when the interaction of limitation of daily activities due to pain with age is considered. Pain is therefore not "strong" enough to modify perception of health unless age is considered. Finally, the moderating effect between limitation of daily activities due to pain and METS and between METs and perception of health is maintained until age 76, approximately. The fact that moderation is lost after 76 years does not imply that older adults should not continue to exercise and obtain benefits because we have focused on a population with limited daily activities due to pain. Besides, we have only assessed the association with energy expenditure, not with the preservation or gain of muscle mass, mobility, balance, improvement of mood, etc. (World Health Organization, 2020).

Because the stated hypotheses were supported, and in response to our second objective, equations predicting energy expenditure (means and 95% CI) according to perceived level of health were calculated. In this way, by entering the perceived level of health, we can estimate the energy expenditure that people who are limited in their daily activities due to pain should have and vice versa (Fig. 4). Therefore, this approach could represent a way to dose physical activity to treat pain in these people. Furthermore, tables of physical activity and energy expenditure in METs are readily available (Ainsworth et al., 2011), and there are many applications for their computations (Kozey et al., 2010).

Limitations and Strengths

As limitations, we should point out that we have not analyzed variables that may be interacting with perceived health, such as socioeconomic or educational level. Likewise, our sample comes from a survey, so biases related to data collection through questionnaires must be considered and the results can only be extrapolated to the Spanish population.

As for strengths, the absence of similar studies in the literature, the large sample size, and the innovative orientation of the statistical approach, which allowed causal relationships to be established, should be emphasized (Hayes & Rockwood, 2017; Igartua & Hayes, 2021). The applicability of our results should also be considered positively.

Conclusion

The perception of health in people who have limited activities of daily living due to pain (moderate to severe) is mediated by the amount of physical activity they perform and by age (up to 76 years). The proposed equations calculate METs (with mean and upper and lower limits, with 95% CI) according to the level of perceived health to be achieved.

All nursing professionals should be trained in the assessment and management of pain. During nursing assessment, nurses should collect data about patients' limitations in their daily activities due to pain and the level of physical activity they perform. Then, these professionals can use tools, such as the equation proposed in this study, to determine whether the level of physical activity can be modified to improve these patients' perceived level of health. The supplementary material and website under development can extend this resource to all nurses who care for patients affected by this problem that greatly reduces their quality of life.

Clinical Implications

An exhaustive nursing assessment of the physical activities performed by patients, together with the analysis and interpretation of the findings collected through clinical records and tools, such as the proposed formula, will lead to the formulation of nursing diagnoses that will allow for the development of realistic and objectifiable objectives jointly with the patient. The NANDA International 2021-2023 lists four diagnoses concerning pain: [00132] Acute pain, [00133] Chronic pain, [00225] Chronic pain syndrome, and [00256] Labor pain, with outcome criteria mainly oriented around (2102) Pain level, (1605) Pain control, (1843) and Knowledge: pain management (Moorhead, 2019).

Nurses could use the proposed formula to calculate the energy expenditure of patients and guide them to develop physical activities to help them improve their perceived level of health. Consequently, this tool could lead to proper pain management, prescribing physical activity and increasing the perceived health level in patients.

Let's imagine patients experiencing pain during daily activities and negatively perceiving their health. To determine whether their energy expenditure is insufficient and establish an activity plan to help the patient reach an optimal level of health, specific data such as age, weight and height, and time spent in light are obtained; moderate and vigorous activities are needed. With this information, it is possible to determine how much energy expenditure the patient needs and agree on a specific activity plan to reach that goal. A downloadable Excel file has been created, and the http://calculator.ohnweb.es/ website is also being developed (beta testing phase) to compute these calculations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.pmn.2023.04.013.

References

Ainsworth, B. E., Haskell, W. L., Herrmann, S. D., Meckes, N., Bassett, D. R. J., Tudor-Locke, C., Greer, J. L., Vezina, J., Whitt-Glover, M. C., & Leon, A. S. (2011). 2011 Compendium of physical activities: A second update of codes and MET values. *Medicine and Science in Sports and Exercise, 43*(8), 1575–1581.

Alnajar, M. K., Darawad, M. W., Alshahwan, S. S., & Samarkandi, O. A. (2019). Knowledge and attitudes toward cancer pain management among nurses at oncology units. *Journal of Cancer Education, 34*(1), 186–193.

Al-Atiyyat, N., Salim, N. A., Tuffaha, M. G., Abu Nigim, H. A., Saleh, M. M. d., Alkhodary, M. E., & Brant, J. M. (2019). A survey of the knowledge and attitudes of oncology nurses toward pain in United Arab Emirates oncology settings. *Pain Management Nursing, 20*(3), 276–283.

Alzahrani, H., Mackey, M., Stamatakis, E., Zadro, J. R., & Shirley, D. (2019). The association between physical activity and low back pain: A systematic review and meta-analysis of observational studies. *Scientific Reports, 9*(1), 8244.

Belavy, D. L., Van Oosterwijck, J., Clarkson, M., Dhondt, E., Mundell, N. L., Miller, C. T., & Owen, P. J. (2021). Pain sensitivity is reduced by exercise training: Evidence from a systematic review and meta-analysis. *Neuroscience & Biobehavioral Reviews, 120*, 100–108.

Booth, J., Moseley, G. L., Schiltenwolf, M., Cashin, A., Davies, M., & Hübscher, M. (2017). Exercise for chronic musculoskeletal pain: A biopsychosocial approach. *Musculoskeletal Care, 15*(4), 413–421.

Bruehl, S., Burns, J. W., Koltyn, K., Gupta, R., Buvanendran, A., Edwards, D., Chont, M., Wu, Y. H., Qu'd, D., & Stone, A. (2020). Are endogenous opioid mechanisms involved in the effects of aerobic exercise training on chronic low back pain? A randomized controlled trial. *Pain, 161*(12), 2887–2897.

Bruehl, S., Burns, J. W., Koltyn, K., Gupta, R., Buvanendran, A., Edwards, D., Chont, M., Wu, Y. H., & Stone, A. (2021). Does aerobic exercise training alter responses to opioid analgesics in individuals with chronic low back pain? A randomized controlled trial. *Pain, 162*(8), 2204–2213.

Caramés-Álvarez, M. Á., & Navarro-Ribero, M. (2016). Costes del tratamiento del dolor versus su no tratamiento. Aproximación a la realidad de Portugal y España. *Dor, 24*, 1–9.

Chavarrías-Hernández, C. (2020). *Self-perceived health in Spain and its determinants*. Universidad de Zaragoza.

Frutiger, M., & Borotkanics, R. (2021). Systematic review and meta-analysis suggest strength training and workplace modifications may reduce neck pain in office workers. *Pain Practice: The Official Journal of World Institute of Pain, 21*(1), 100–131.

García-Correa, H. R., Sánchez-Montoya, L. J., Daza-Arana, J. E., & Ordoñez-Mora, L. T. (2021). Aerobic physical exercise for pain intensity, aerobic capacity, and quality of life in patients with chronic pain: A systematic review and meta-analysis. *Journal of Physical Activity & Health, 18*(9), 1126–1142.

Gil-García, E., & Cáceres Matos, R.. *Dolor crónico: consencuencias en la salud de las mujeres* Retrieved November 8, 2022, from. https://www.easp.es/wp-content/uploads/2020/07/05_dolor-cronico.pdf.

Hadgraft, N. T., Lynch, B. M., Clark, B. K., Healy, G. N., Owen, N., & Dunstan, D. W. (2015). Excessive sitting at work and at home: Correlates of occupational sitting and TV viewing time in working adults. *BMC Public Health, 15*(1), 1–14.

Hayes, A. F., & Rockwood, N. J. (2017). Regression-based statistical mediation and moderation analysis in clinical research: Observations, recommendations, and implementation. *Behaviour Research and Therapy, 98*, 39–57.

Henriksen, M., Hansen, J. B., Klokker, L., Bliddal, H., & Christensen, R. (2016). Comparable effects of exercise and analgesics for pain secondary to knee osteoarthritis: A meta-analysis of trials included in Cochrane systematic reviews. *Journal of Comparative Effectiveness Research, 5*(4), 417–431.

Igartua, J. J., & Hayes, A. F. (2021). Mediation, moderation, and conditional process analysis: Concepts, computations, and some common confusions. 24(e49), 1-23.

Jetté, M., Sidney, K., & Blümchen, G. (1990). Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. *Clinical cardiology, 13*(8), 555–565.

Latina, R., Mauro, L., Mitello, L., D'Angelo, D., Caputo, L., De Marinis, M. G., & Baglio, G (2015). Attitude and knowledge of pain management among italian nurses in hospital settings. *Pain Management Nursing, 16*(6), 959–967.

Kami, K., Tajima, F., & Senba, E. (2022). Brain mechanisms of exercise-induced hypoalgesia: To find a way out from "fear-avoidance belief. *International Journal of Molecular Sciences*, (5), 23.

Kozey, S., Lyden, K., Staudenmayer, J., & Freedson, P. (2010). Errors in MET estimates of physical activities using 3.5 ml x kg(-1) x min(-1) as the baseline oxygen consumption. *Journal of Physical Activity & Health, 7*(4), 508–516.

Mantilla-Toloza, S. C., & Gómez-Conesa, A. (2007). International Physical Activity Questionnaire. An adequate instrument in population physical activity monitoring. *Revista Iberoamericana de Fisioterapia y Kinesiología, 10*(1), 48–52.

Ministerio de Sanidad, Servicios Sociales e Igualdad. (2017). Indicadores de salud 2017. Evolución de los indicadores de estado de salud en España y su magni-

tud en el contexto de la Unión Europea. Retrieved November 11, 2022, from https://www.sanidad.gob.es/estadEstudios/estadisticas/inforRecopilaciones/docs/Indicadores_de_Salud_2020.pdf

Ministerio de Sanidad, Consumo y Bienestar Social. (2017). Encuesta Nacional de Salud de España 2017 (ENSE 2017). Retrieved November 11, 2022, from https://www.sanidad.gob.es/estadEstudios/estadisticas/encuestaNacional/encuesta2017.htm

Moorhead, S. (2019). *Clasificación de resultados de enfermería (NOC) : Medición de resultados en salud en salud* (Elsevier, Ed.).

Morcillo-Cebolla, V. (2017). *Inequalities in self-perceived health in the Spanish population*. Universidad Autonoma de Madrid.

Morris, J. N., Heady, J. A., Raffle, P. A., Roberts, C. G., & Parks, J. W. (1953). Coronary heart-disease and physical activity of work. *Lancet (London, England), 262*(6795), 1053–1057.

Naugle, K. M., Fillingim, R. B., & Riley, J. L., 3rd (2012). A meta-analytic review of the hypoalgesic effects of exercise. *The Journal of Pain, 13*(12), 1139–1150.

Pérez-Soto, J., & García Cantó, E. (2012). Measurement of physical activity using the International Physical Activity Questionnaire (IPAQ) in Spanish and international studies. *Revista Electrónica Actividad Física y Ciencias, 4*(2), 1–21.

Pérez-López, A., Valadés-Cerrato, D., & Buján-Varela, J. (2017). Sedentarismo y actividad física. *Revista de Investigación y Educación En Ciencias de La Salud (RIECS), 2*(1), 49–58.

Polaski, A. M., Phelps, A. L., Kostek, M. C., Szucs, K. A., & Kolber, B. J. (2019). Exercise-induced hypoalgesia: A meta-analysis of exercise dosing for the treatment of chronic pain. *PloS One, 14*(1), Article e0210418.

Saint-Maurice, P. F., Graubard, B. I., Troiano, R. P., Berrigan, D., Galuska, D. A., Fulton, J. E., & Matthews, C. E. (2022). Estimated number of deaths prevented through increased physical activity among US adults. *JAMA Internal Medicine, 182*(3), 349–352.

Sánchez-Cruz, J. J., García-Fernández, L., & Mayoral-Cortés, J. M. (2017). Encuesta de Salud de Andalucía. Salud en Andalucía: Adultos. V Encuesta de Salud de Andalucía (Adultos) 2015-2016. https://www.juntadeandalucia.es/export/drupaljda/La Salud en Andalucía- Adultos.pdf

Takahara-Yamauchi, R., Ikemoto, H., Okumo, T., Sakhri, F. Z., Horikawa, H., Nakamura, A., Sakaue, S., Kato, M., Adachi, N., & Sunagawa, M. (2021). Analgesic effect of voluntary exercise in a rat model of persistent pain via suppression of microglial activation in the spinal cord. *Biomedical Research (Tokyo, Japan), 42*(2), 67–76.

Torralba, A., Miquel, A., & Darba, J. (2014). Situación actual del dolor crónico en España: Iniciativa "pain proposal. *Revista de La Sociedad Española Del Dolor, 21*(1), 16–22.

Turner, B. J., Rodriguez, N., Valerio, M. A., Liang, Y., Winkler, P., & Jackson, L. (2017). Less exercise and more drugs: How a low-income population manages chronic pain. *Archives of Physical Medicine and Rehabilitation, 98*(11), 2111–2117.

Utne, I., Småstuen, M. C., & Nyblin, U. (2019). Pain knowledge and attitudes among nurses in cancer care in Norway. *Journal of Cancer Education, 34*(4), 677–684.

Valencia International University. (2017). Self-perceived health, a multidimensional phenomenon of great interest in the field of health research. Our Experts. Retrieved November 9, 2022, from https://www.universidadviu.es/self-perceived-health-a-multidimensional-phenomenon-of-great-interest-in-the-field-of-health-research-our-experts/

Vilagut, G., Ferrer, M., Rajmil, L., Rebollo, P., Permanyer-Miralda, G., Quintana, J. M., Santed, R., Valderas, J. M., Ribera, A., Domingo-Salvany, A., & Alonso, J. (2005). El Cuestionario de Salud SF-36 español: Una década de experiencia y nuevos desarrollos. *Gaceta Sanitaria, 19*(2), 135–150.

World Confederation for Physical Therapy. (2020). How to measure physical activity? [Infographic]. Retrieved November 11, 2020, from https://world.physio/sites/default/files/2020-05/MeasuringPhysicalActivity_infographic_A4_FINAL_Spanish.pdf

World Health Organization. (2020). Physical Activity. Retrieved November 7, 2020, from https://www.who.int/news-room/fact-sheets/detail/physical-activity

Zhang, S. K., Yang, Y., Gu, M. L., Mao, S. J., & Zhou, W. S. (2022). Effects of low back pain exercises on pain symptoms and activities of daily living: A systematic review and meta-analysis. *Perceptual and Motor Skills, 129*(1), 63–89.