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Physical pain as a component of subjective wellbeing

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Subjective wellbeing (SWB) is a self-reported construct of wellbeing including components like life satisfaction, and positive and negative affect. We explore the role of physical pain in the construct of SWB using data from the Global Flourishing Study (22 countries, _N_ = 187,160) and the Gallup World Poll (163 countries, _N_ = 2,048,494). Consistent with the existing understanding of physical pain, we document that people can experience negative affect-related pain in the absence of physical health problems, and with near perfect physical health. We also find that the current components of SWB are not perfect proxies for pain and that physical pain and other components of negative affect like stress, worry, anxiety, anger, and sadness load on the same factor in principal component factor analysis. Based on this empirical evidence, we suggest that physical pain can be included in the construct of SWB as a component of negative affect. This proposition has the potential to advance the field in the coming decades by providing a better understanding of people's wellbeing, presenting alternative methods to measure SWB, and informing the design of wellbeing interventions.

Keywords Subjective wellbeing (SWB), Life satisfaction, Physical pain, Negative affect, Stress, Physical health

Throughout history, human wellbeing has received a great deal of attention. From ancient thinkers like Aristotle to current government leaders around the world, different agents have focused on how to improve wellbeing[1–4]. As a result, debates about how best to capture people's wellbeing have been held in the philosophical, scientific, and policymaking spheres. More recently, individuals' wellbeing has been captured through the well-established construct of subjective wellbeing (SWB) which involves self-reported aspects of people's wellbeing. For instance, The Organisation for Economic Co-operation and Development (OECD) defines SWB as "good mental states, including all of the various evaluations, positive and negative, that people make of their lives, and the affective reactions of people to their experiences."[1; p. 29] In some conceptions[1], SWB involves three dimensions with different components: (1) The hedonic dimension includes components of positive affect (e.g., joy and happiness) and negative affect (e.g., sadness and worry), (2) the evaluative dimension contains overall life satisfaction and domain satisfactions like satisfaction with work and family[5], and (3) the eudaimonic dimension includes sense of fulfilment in life represented, for example, by purpose or meaning[6]. However, whether the current components of SWB are sufficiently comprehensive to capture all aspects of people's wellbeing remains an open inquiry.

One other aspect of human experience that has received extensive attention from researchers across the social sciences is physical pain (i.e., an unpleasant bodily sensation)[7]. Although physical pain has typically been linked to physical injuries, the long-standing idea that it can also be influenced by psychosocial factors is now well-established[8]. The biopsychosocial model of pain suggests that there is a dynamic interaction between physical pain and biological, psychological, and social factors[9–12]. Related work has found that negative emotions like stress or worry can impact upon experiences of physical pain[13,14]. However, the existing literature is relatively silent on whether physical pain should be included in the construct of subjective wellbeing. Based on these ideas, the present article investigates whether physical pain ought to be considered a component of negative affect in the construct of SWB used in the SWB literature rather than exclusively a symptom of physical health problems.

The existing components of SWB have been widely used by economists, psychologists, and behavioural scientists for more than half a century. In 2013, the OECD published guidelines on measuring SWB supporting the current components and highlighting the potential of SWB to inform wellbeing policymaking[1]. In line with these efforts, a large body of work has examined the link between SWB and a wide range of factors. One of many examples includes the positive association of happiness and life satisfaction with socioeconomic aspects like income[15,16], and level of education[17], and with behavioural factors like prosocial behaviour, and social connection[18]. Other examples include the extensive work on the negative association of life satisfaction

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and positive affect with personal unemployment[19], and the unemployment rate[20]. At the same time, negative emotions have been found to be positively linked to other work arrangements like underemployment and overemployment[21] as well as to economic insecurity[22].

An empirical parallelism can be found between the existing literature on SWB and the relatively new research on physical pain. For instance, recent work has documented that physical pain tends to be greater in countries with higher unemployment rate[23] and among individuals who are unemployed[24], underemployed[25], less educated[26], in the lowest income quintile[27], and economically insecure[14]. Some behaviours have been found to be protective against physical pain. For instance, engaging in prosocial behaviours like donating money to charity and volunteering time to an organisation[28] as well as having meaningful social connections[29] seem to ease physical pain.

Despite the similarities across both bodies of work, empirical evidence linking both fields and assessing the role of physical pain as a component of SWB is relatively scarce. We address this gap with several statistical tests. Building on the idea that physical pain can also be influenced by psychosocial factors, we first examine whether negative affect-related pain can exist *above and beyond* physical health problems. We then explore the link between the existing components of SWB and physical pain, and the role of pain in the current conceptualization of SWB. Thus, this study explores the following hypotheses:

Hypothesis 1 There will be a significantly positive association between negative affect and physical pain after controlling for physical health.

Hypothesis 2 There will be a significantly positive association between negative affect and physical pain among people who report that their physical health is near perfect and those who report that they do not have health problems.

Hypothesis 3 The existing components of SWB will not be highly correlated with physical pain.

Hypothesis 4 Physical pain and negative affect will load on the same underlying factor in principal component factor analysis.

To explore these hypotheses, we examined data from the Global Flourishing Study (GFS, 22 countries, 2023, $N = 187,160$) and the Gallup World Poll (GWP, 163 countries, 2005–2024, $N = 2,048,494$), using Ordinary Least Squares regressions with a wide set of demographic characteristics, country, and year fixed effects, and principal component factor analysis.

Results

The sample for our Global Flourishing Study was comprised of 47% males (s.d.= 0.499), respondents' age ranged from 18 to 99 (Mean = 45.813, s.d.= 17.558), and the mean of our 1–4 pain dependent variable was 2.336 (s.d.= 0.956). Our Gallup World Poll sample was comprised of 46% males (s.d.= 0.499), respondents' age ranged from 15 to 100 (Mean = 41.8, s.d.= 17.887), and 31% of people experienced physical pain the day before (s.d.= 0.463, range = 0–1). Description of variables across both datasets can be found in the Methods section below, and in Text S.1 and Text S.2 in the Supplementary Materials (SM). Descriptive statistics for the variables used in the analyses can be found in Table S1 and S2 in the SM.

Tables 1 and 2 show regression models related to hypothesis 1. Using data from the Global Flourishing Study, Table 1 shows Ordinary Least Squares regressions using physical pain as the dependent variable and different components of negative affect as the main independent variables. Across all models, there was a significantly positive association between negative affect and physical pain: People who reported having felt more anxious (vs. less; $b = 0.298$, $p < .001$, 95%CI [0.294, 0.302]), more depressed (vs. less; $b = 0.308$, $p < .001$, 95%CI [0.303, 0.312]), greater distress (vs. less; $b = 0.319$, $p < .001$, 95%CI [0.315, 0.323]), and greater financial worry (vs. less; $b = 0.053$, $p < .001$, 95%CI [0.051, 0.054]) reported greater physical pain. These findings can be found in column 1 of Table 1. The significantly positive coefficient of negative affect and pain held after accounting for whether people had health problems (column 2) and people's physical health assessment (column 3) in separate regressions as well as when including both physical health variables (i.e., health problems and physical health assessment) together in the same regression model (column 4). All findings held after controlling for demographic characteristics and country fixed effects (see Tables S4 to S7 in the Supplementary Materials for full models).

It is worth looking at the negative affect-physical pain coefficient when including health covariates in the regression models. For instance, the relationship between feeling anxious and physical pain goes from 0.298 when no health covariates are included (column 1) to 0.254 when having health problems is accounted for (column 2) showing a 15% reduction (1−0.254/0.298). This suggests that the health problems variable can explain only 15% of the association between feeling anxious and physical pain. Similarly small reductions can be found across the other negative affect variables. When including health problems in the regressions, there is a 16% reduction in the feeling depressed coefficient (1−0.260/0.308), 13% in the traumatic distress coefficient (1−0.278/0.319), and 19% in the financial worry coefficient (1−0.043/0.053). This suggests that the health problems variable can only explain a small proportion of the relationship between negative affect and physical pain. A similar small reduction can also be seen when controlling for people's physical health assessment (column 3) and health problems and physical health variables together (column 4) suggesting that the overall explained proportion is still rather small.

Table 2 conducts the same analyses using data from the Gallup World Poll. Once again, these results revealed a significantly positive association between negative affect and physical pain: People who reported more sadness (vs. less; $b = 0.257$, $p < .001$, 95%CI [0.256, 0.258]), anger (vs. less; $b = 0.206$, $p < .001$, 95%CI [0.204, 0.207]), stress

	Dependent variable: Physical pain (1–4)			
	No health controls (1)	+ physical health (2)	+ health problems (3)	+ physical health + health problems (4)
Feeling anxious	0.298***	0.254***	0.229***	0.210***
Health problems	–	0.608***	-	0.458***
Physical health	–	–	-0.117***	– 0.092***
Feeling depressed	0.308***	0.260***	0.233***	0.213***
Health problems	–	0.601***	–	0.456***
Physical health	–	–	– 0.115***	– 0.091***
Traumatic distress	0.319***	0.278***	0.269***	0.249***
Health problems	–	0.589***	–	0.428***
Physical health	–	–	-0.118***	– 0.095***
Financial worry	0.053***	0.043***	0.029***	0.027***
Health problems	–	0.679***	–	0.502***
Physical health	–	–	– 0.132***	– 0.104***

Table 1. Physical pain and negative affect. The Global Flourishing Study. Note: $*p < .05$; $**p < .01$; $***p < .001$. Table shows unstandardised coefficients from Ordinary Least Squares regressions. $N = 187,160$. 2023, 22 countries. Column 1 shows the coefficients from the regression models that include demographic characteristics (age, age squared, gender, level of education, employment status, marital status, income, and number of children under 15 in the household), and the indicated variable of negative affect without variables of physical health. Each negative affect variable was included in a different regression. Column 2 adds health problems, Column 3 adds physical health, and Column 4 adds both health problems, and physical health to the micro-econometric regressions. Full models can be found in Tables S4 to S7. Physical health and health problems correlation is -0.36. *Physical pain* How much bodily pain have you had during the past 4 weeks? A lot, some, not very much, or none at all? None at all (1), Not very much (2), Some (3), A lot (4). *Health problems* Do you have any health problems that prevent you from doing any of the things people your age normally can do? Yes, No. *Physical health* In general, how would you rate your PHYSICAL health? Please use a 0 to 10 scale where 10 means excellent physical health and 0 means poor physical health. You can use any number between 0 and 10.

(vs. less; $b = 0.218$, $p < .001$, 95%CI [0.21, 0.219]), and worry (vs. less; $b = 0.252$, $p < .001$, 95%CI [0.251, 0.253]) reported greater physical pain. These findings held after controlling for having health problems (column 2) and whether people found their physical health to be near perfect (column 3) in separate regressions as well as when accounting for these two factors in the same regression model (column 4). All findings held after controlling for demographic characteristics and country and year fixed effects (see Tables S8 to S11 in the SM for full models).

The reduction in the negative affect-physical pain coefficients when controlling for health problems (column 2) is also again small. For instance, when controlling for health problems the sadness coefficient was reduced by 14% meaning that health problems can explain 14% of the relationship between sadness and physical pain. The same small reduction can be found across the other negative affect components. For instance, there was a 11% reduction in the anger coefficient, a 12% in the stress coefficient, and a 12% in the worry coefficient. The same relatively small reductions can be found when including health near perfect (column 3) and both variables of physical health together in the same model (column 4).

The models shown in Tables 1 and 2 support hypothesis 1 of this study: There is a significantly positive association between negative affect and physical pain after controlling for physical health.

Tables 3 and 4 show the regression models that were conducted to explore hypothesis 2. Models in Table 3 used data from the two datasets to explore the link between negative affect and physical pain among those who had health problems and those who did not. Panel A uses data from the Global Flourishing Study and shows a significantly positive association between negative affect and physical pain among people who reported to have health problems (column 1) and those who reported not to have health problems (column 2). For instance, among those with health problems, people who reported having felt more anxious (vs. less; $b = 0.199$, $p < .001$, 95%CI [0.191, 0.207]), more depressed (vs. less; $b = 0.206$, $p < .001$, 95%CI [0.197, 0.214]), greater distress (vs. less; $b = 0.227$, $p < .001$, 95%CI [0.219, 0.235]), and greater financial worry (vs. less; $b = 0.040$, $p < .001$, 95%CI [0.0373, 0.043]) reported higher physical pain. Virtually identical, but slightly stronger, associations were found among those without health problems: people who reported having felt more anxious (vs. less; $b = 0.272$, $p < .001$, 95%CI [0.267, 0.277]), more depressed (vs. less; $b = 0.279$, $p < .001$, 95%CI [0.273, 0.283]), greater distress (vs. less; $b = 0.291$, $p < .001$, 95%CI [0.286, 0.295]), and greater financial worry (vs. less; $b = 0.044$, $p < .001$, 95%CI [0.042, 0.045]) reported higher physical pain. These findings held after controlling for demographic characteristics and country fixed effects (see Tables S12 and S13 in the SM for full models).

Panel B of Table 3 uses data from the Gallup World Poll and also shows a significantly positive association between negative affect and physical pain among people who reported to have health problems (column 1) and those who reported not to have health problems (column 2). Among those who reported to have health problems, people who reported more sadness (vs. less; $b = 0.245$, $p < .001$, 95%CI [0.242, 0.247]), anger (vs. less;

	Dependent variable: Physical pain (0–1)			
	No health controls (1)	+ health problems (2)	+ health near perfect (3)	+ health problems + health near perfect (4)
Sadness	0.257***	0.222***	0.215***	0.201***
Health problems	–	0.248***	–	0.190***
Health near perfect	–	–	– 0.084***	-0.059***
Anger	0.206***	0.183***	0.178***	0.170***
Health problems	–	0.266***	–	0.201***
Health near perfect	–	–	– 0.090***	– 0.063***
Stress	0.218***	0.192***	0.177***	0.168***
Health problems	–	0.256***	–	0.197***
Health near perfect	–	–	– 0.086***	– 0.060***
Worry	0.252***	0.222***	0.208***	0.196***
Health problems	–	0.243***	–	0.188***
Health near perfect	–	–	– 0.081***	– 0.057***

Table 2. Physical pain and negative affect. The Gallup World Poll. Note: *$p < .05$; **$p < .01$; ***$p < .001$. Table shows unstandardised coefficients from Ordinary Least Squares regressions. Columns 1 and 2: $N = 2,048,494$; 2009–2024. Columns 3 and 4: 399,310; 2013–2016. 163 countries. Column 1 shows the coefficients from the regression models that include demographic characteristics (age, age squared, gender, level of education, employment status, marital status, income, and number of children under 15 in the household), country and year fixed effects, and the indicated variable of negative affect without variables of physical health. Each negative affect variable was included in a different regression. Column 2 adds health problems, Column 3 adds health near perfect, and Column 4 adds health problems and health near perfect to the micro-econometric regressions. Full models can be found in Tables S8 to S11. Health problems and health near prefect correlation is − 0.47. *Physical pain* Did you experience the following feelings during a lot of the day yesterday? How about physical pain? Yes (1), No (0). *Health problems* Do you have any health problems that prevent you from doing any of the things people your age normally can do? Yes,No. *Health near perfect* Thinking about your life in general, please rate your level of agreement with each of the following using a five-point scale, where 5 means you STRONGLY AGREE and 1 means you STRONGLY DISAGREE. You may choose any of the numbers 1, 2, 3, 4, or 5. Your physical health is near-perfect.

$b = 0.188$, $p < .001$, 95%CI [0.185, 0.191]), stress (vs. less; $b = 0.231$, $p < .001$, 95%CI [0.228, 0.234]), and worry (vs. less; $b = 0.287$, $p < .001$, 95%CI [0.284, 0.289]) reported greater physical pain. Similarly, among those who reported not to have health problems, people who reported more sadness (vs. less; $b = 0.208$, $p < .001$, 95%CI [0.206, 0.210]), anger (vs. less; $b = 0.181$, $p < .001$, 95%CI [0.179, 0.182]), stress (vs. less; $b = 0.176$, $p < .001$, 95%CI [0.174, 0.177]), and worry (vs. less; $b = 0.195$, $p < .001$, 95%CI [0.194, 0.196]) reported greater physical pain. These findings held after controlling for demographic characteristics and country and year fixed effects (see Tables S14 and S15 in the SM for full models). Models in both panels of Table 3 suggest that there is a strong association between negative affect and physical pain even for those who do not have health problems.

Table 4 shows additional subset analyses using data from the Gallup World Poll. In line with prior findings, we found a significantly positive association between negative affect and physical pain among people who reported that their health was not near perfect (1 and 2 in the 1–5 question, column 1) and those who reported that their health was near perfect (4 and 5 in the 1–5 question, column 2). Among those who reported that their health was not near perfect, there was a significantly positive association between sadness ($b = 0.228$, $p < .001$, 95%CI [0.251, 0.253]), anger ($b = 0.179$, $p < .001$, 95%CI [0.171, 0.186]), stress ($b = 0.211$, $p < .001$, 95%CI [0.204, 0.218]), worry ($b = 0.269$, $p < .001$, 95%CI [0.262, 0.276]) and physical pain. Similarly, among those who reported that their health was near perfect, there was a significantly positive association between sadness ($b = 0.201$, $p < .001$, 95%CI [0.196, 0.205]), anger ($b = 0.173$, $p < .001$, 95%CI [0.168, 0.177]), stress ($b = 0.162$, $p < .001$, 95%CI [0.158, 0.165]), worry ($b = 0.179$, $p < .001$, 95%CI [0.175, 0.182]) and physical pain. These results held after controlling for demographic characteristics and country and year fixed effects (see Tables S16 and S17 in the SM for full models). These findings suggest that there is a strong association between negative affect and physical pain even for those who reported that their physical health was near perfect. We also conducted the same analyses with a subsample of people who reported 5 in the near perfect health question and obtained virtually identical relationships (see Table S18 in the SM). Moreover, 19.4% of people reported physical pain even when reporting the highest possible number in the near perfect health question also suggesting that pain can exist in the absence of physical health issues.

Findings shown in Tables 3 and 4 support hypothesis 2 of this study: There is a significantly positive association between negative affect and physical pain among people who report that their physical health is near perfect and those who report that they do not have health problems.

We conducted several robustness checks. First, building on prior work that used the variables of negative affect available in the Gallup World Poll in an index[30], we conducted the analyses with the GWP using an index of the four negative affect variables (i.e., average of sadness, stress, worry, and anger). The resulting variable

	Panel A: The Global Flourishing Study	
	Dependent variable: Physical pain (1–4)	
	Health problems - Yes (1)	Health problems - No (2)
Feeling anxious	0.199***	0.272***
Feeling depressed	0.206***	0.279***
Traumatic distress	0.227***	0.291***
Financial worry	0.040***	0.044***
	Panel B: The Gallup World Poll	
	Dependent variable: Physical pain (0–1)	
	Health problems - Yes (1)	Health problems - No (2)
Sadness	0.245***	0.208***
Anger	0.188***	0.181***
Stress	0.231***	0.176***
Worry	0.287***	0.195***

Table 3. Pain and negative affect across health problems. The Global Flourishing Study and the Gallup World Poll. Note: *$p < .05$; **$p < .01$; ***$p < .001$. Table shows unstandardised coefficients from Ordinary Least Squares regressions in each subset that include demographic characteristics (age, age squared, gender, level of education, employment status, marital status, income, and number of children under 15 in the household), country (and year in the GWP equations) fixed effects, and the indicated variable of negative affect. Each negative affect variable was included in a different regression. Full models can be found in Tables S12 to S15. The Global Flourishing Study - Column 1: $N = 39{,}319$; Column 2: 147,841. 2023, 22 countries. The Gallup World Poll - Column 1: $N = 506{,}385$; Column 2: 1,542,109. 2009–2024, 163 countries. *Physical pain (GFS)* How much bodily pain have you had during the past 4 weeks? A lot, some, not very much, or none at all? None at all (1), Not very much (2), Some (3), A lot (4). *Physical pain (GWP)* Did you experience the following feelings during a lot of the day yesterday? How about physical pain? Yes (1), No (0). *Health problems* Do you have any health problems that prevent you from doing any of the things people your age normally can do? Yes, No.

ranged from 0 to 1 with relatively high internal reliability (Cronbach's alpha = 0.69). These additional models yielded the same conclusions as the ones that used each measure of negative affect separately and can be found in Table S19 in the SM. Second, we conducted Binary logistic regressions with the GWP and Ordered logistics regressions with the GFS. These alternative methods produced substantively similar conclusions: negative affect and physical pain were significantly positively associated even after controlling for health problems, physical health assessment, physical health near perfect and demographic characteristics, and among the relevant health problems and health near perfect subsamples. These models are presented in Tables S20 to S33 in the SM.

Figure 1 shows the correlations conducted to examine hypothesis 3. Panel A in Fig. 1 uses data from the Global Flourishing Study and shows correlations between physical pain and existing components of subjective wellbeing like life satisfaction, life evaluation, purpose in life, meaning in life, happiness, financial worry, feeling depressed, and feeling anxious. Panel B in Fig. 1 uses data from the Gallup World Poll and shows correlations between physical pain and other components of subjective wellbeing like life satisfaction, purpose in life, happiness, enjoyment, stress, worry, sadness, anger, job satisfaction, satisfaction with standard of living, satisfaction with health, and satisfaction with city. Across both datasets, results reveal that the correlation between physical pain and the current components of SWB is relatively low ranging from − 0.28 to 0.30. These findings show that the current components of SWB are not perfect substitutes for measuring physical pain demonstrating that physical pain has discriminant validity regarding the existing components of SWB (i.e., items are not closely associated with each other). Although there is no firm threshold to assess discriminant validity, a correlation below 0.7 is sometimes considered acceptable to determine that discriminant validity exists between two variables[31]. These results confirm hypothesis 3 of this study: The existing components of subjective wellbeing are not highly correlated with physical pain.

Table 5 shows the results from the principal component factor analysis we conducted to examine hypothesis 4. Given that the focus of this study is the presence of physical pain when there are no physical health problems, Table 5 shows the principal component factor analysis among people who reported that they did not have health problems. The same analyses with the full sample with and without age, a demographic factor strongly related to pain and physical health, can be found in Tables S34, S35 and S36 in the SM with the corresponding scree plots in Figs. S1 and S2 (see below for more details about these results).

Panel A of Table 5 shows the results using the Global Flourishing Study data for which three factors were retained (see Fig. S3 in the SM). These results show that physical pain (0.606) and variables of negative affect like feeling anxious (0.754), feeling depressed (0.732), distress (0.698), and financial worry (0.45) have the largest loadings on factor 2 which seems to represent negative affective subjective wellbeing. Factor 1 appears to represent positive subjective wellbeing with measure like life satisfaction, and happiness having the largest loadings.

	Dependent variable: Physical pain (0–1)	
	Physical health not near perfect (1)	Physical health near perfect (2)
Sadness	0.228***	0.201***
Anger	0.179***	0.173***
Stress	0.211***	0.162***
Worry	0.269***	0.179***

Table 4. Pain and negative affect across physical health status. The Gallup World Poll. Note: *$p < .05$; **$p < .01$; ***$p < .001$. Table shows unstandardised coefficients from Ordinary Least Squares regressions in each subset that include demographic characteristics (age, age squared, gender, level of education, employment status, marital status, income, and number of children under 15 in the household), country and year fixed effects, and the indicated variable of negative affect. Each negative affect variable was included in a different regression. Full models can be found in Tables S16 and S17. Column 1: $N = 72,326$; Column 2: 240,984. 2013–2016, 163 countries. Subsets were created using the 5-point physical health near perfect variable and classifying people who answered 1 and 2 as 'Physical health **not** near perfect' and 4 and 5 as 'Physical health near perfect.' *Physical pain* Did you experience the following feelings during a lot of the day yesterday? How about physical pain? Yes (1), No (0). *Health near perfect* Thinking about your life in general, please rate your level of agreement with each of the following using a five-point scale, where 5 means you STRONGLY AGREE and 1 means you STRONGLY DISAGREE. You may choose any of the numbers 1, 2, 3, 4, or 5. Your physical health is near-perfect.

Panel B of Table 5 shows the results using the Gallup World Poll for which two factors were retained (see Fig. S4 in the SM). These results show similar conclusions: Physical pain (0.489) and variables of negative affect like stress (0.689), worry (0.713), sadness (0.704), and anger (0.61) again load primarily on the same factor 1 which can represent negative subjective wellbeing. Factor 2 represents positive subjective wellbeing with measures like life evaluation and satisfaction with standard of living having the largest loadings.

Panel A of Table 5 also shows that physical pain (-0.506) loads on factor 3 together with physical health (0.505) in the GFS data. To further understand this result, we conducted additional principal component factor analyses using the full sample without including a measure of age (Table S34), the full sample with age included (Panel A in Table S35 and Panel A in Table S36), and the subsample of respondents with no health problems with age included (Panel B in Table S35 and Panel B in Table S36).

In the analyses of the full sample without age (Table S34), pain once again loads on both the "negative affect" factor and the "health" factor as in Panel A of Table 5. However, in the analyses that include age (Tables S35 and S36), we can see that age also loads highly on factor 3 (e.g., 0.624 in Panel A of Table S35) suggesting that factor 3 may represent health circumstances associated with aging. It may not be surprising that pain also loads on the same factor as physical health because, according to the biopsychosocial model of pain, pain can be influenced by biological *as well as* psychosocial factors. The fact that age also loads highly on that same factor potentially points to the role of age in the pain that might result from having poor physical health. Variables can sometimes load on the same factor due to causal, rather than conceptual, relations[32].

However, our results show that physical pain and negative affect load on the same factor in the full sample and in the subsample of respondents with no health problems. This suggests that physical pain might be better or also understood as a type of negative affect rather than being exclusively a symptom of physical health problems.

These findings provide some further support for hypothesis 4 as physical pain and negative affect often load on the same factor.

Discussion

This study used data from the Global Flourishing Study (GFS, 22 countries, $N = 187,160$) and the Gallup World Poll (GWP, 163 countries, $N = 2,048,494$) to examine whether physical pain ought to be considered a component of negative affect in the construct of SWB rather than exclusively a symptom of physical health problems. To do so, we explore whether negative affect-related pain can exist above and beyond poor physical health and the role of physical pain in the construct of subjective wellbeing.

Across both datasets, we found a significantly positive association between different components of negative affect and physical pain even after controlling for different measures of physical health. Although the coefficient of negative affect and pain was reduced after including the physical health covariates, the reduction was between 11% and 19% depending on the regression model. This suggests that the negative affect-related pain that people might experience is partially but not fully explained by poor physical health. One potential explanation for these results is the differing interpretations of the pain and health questions across individuals. For instance, people might link the question about physical pain to acute pain and the question about health problems to chronic pain. Similarly, our pain variables do not allow us to examine the type of pain people are experiencing like acute or chronic pain. One limitation of these analyses might be lack of objective assessments of physical health like diagnosis of diseases and biomarkers. However, our results are consistent with the large body of work that showed a strong link between pain and psychosocial factors[9].

Furthermore, we found that this association was present among those who reported that they did not have physical health problems and those who reported that their physical health was near perfect. These results

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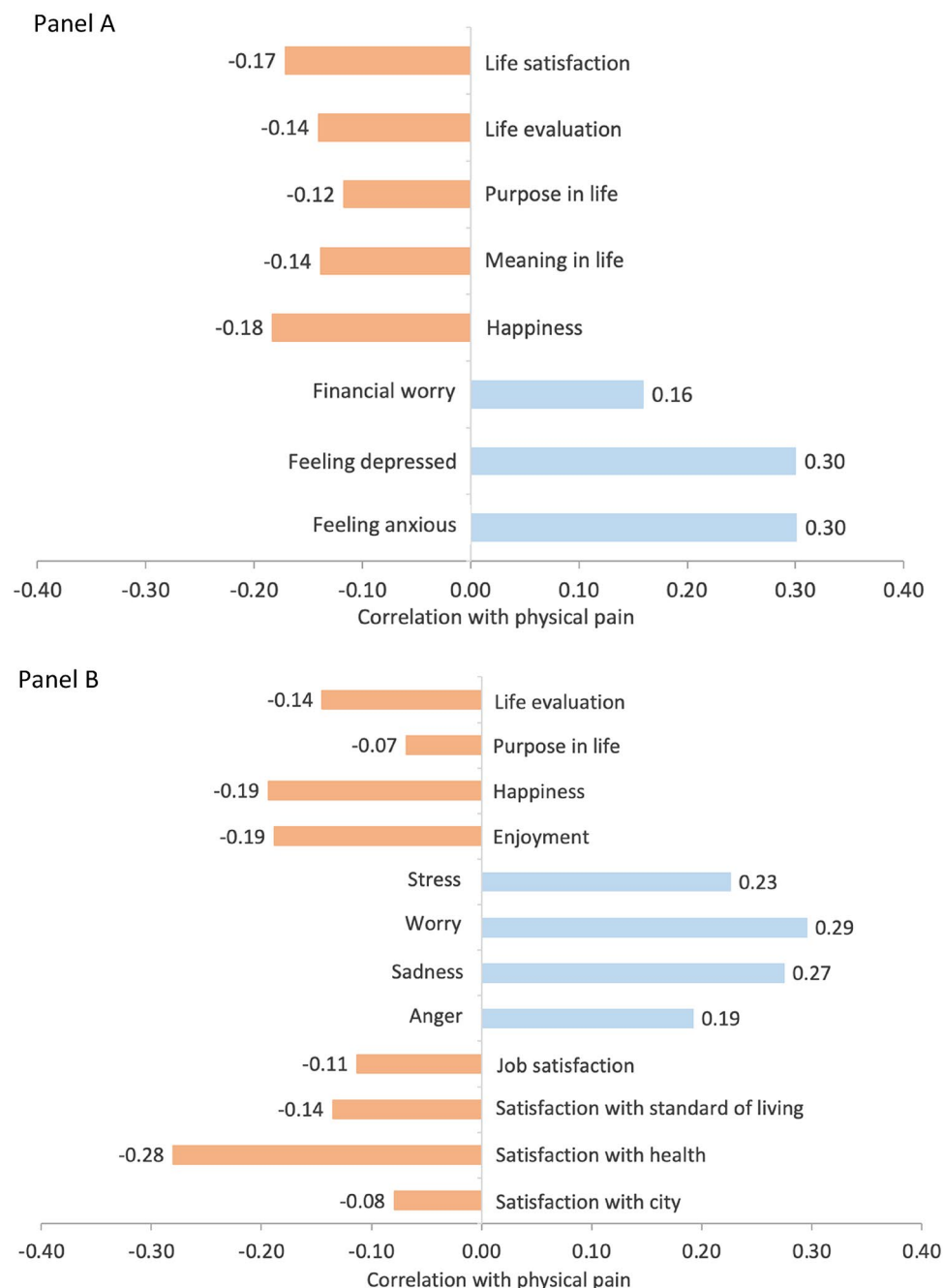
Fig. 1. Panel (**A**) Correlation between variables of subjective wellbeing and physical pain in 22 countries in 2023. 197,839 individual observations. The Global Flourishing Study. Panel (**B**) Correlation between variables of subjective wellbeing and physical pain in 163 countries between 2005 and 2024. 2,209,888 individual observations. The Gallup World Poll. All correlations are significant at the 0.1% level. Sample size exceptions due to data availability: Purpose in life 2005-2011, $N = 151,642$; Happiness 2008-2013, $N = 641,040$; Job satisfaction 2010-2013, $N = 211,486$; Satisfaction with health 2005-2013, $N = 720,774$. All variables are binary (0=No, 1=Yes) except for life satisfaction (0-10).

confirm that one can experience physical pain associated with negative emotions even in good physical health. These findings are in line with prior work that showed that negative emotions are strongly related to physical pain. For instance, one study[13] showed that people who were exposed to experimentally induced negative emotions reported grater physical pain. In a similar study[14], the authors primed people with financial worry and found that those exposed to financial worry reported greater pain.

Although the associations documented here are highly significant, it is important to recognize that statistical significance is expected in large samples like those used in these studies. To mitigate the risk of detecting effects driven solely by sample size, we have implemented rigorous statistical models that included a comprehensive set

Panel A: Global Flourishing Study

Variable	Factor 1	Factor 2	Factor 3	Uniqueness
Meaning in life	0.806	-0.096	0.07	0.336
Happiness	0.8	-0.189	-0.07	0.319
Life satisfaction	0.782	-0.205	-0.176	0.315
Life evaluation	0.662	-0.206	-0.348	0.398
Purpose in life	0.679	-0.003	0.341	0.422
Physical health	0.596	-0.131	0.505	0.372
Feeling anxious	-0.199	0.754	0.058	0.389
Feeling depressed	-0.268	0.732	0.11	0.381
Traumatic distress	-0.028	0.698	-0.089	0.504
Financial worry	-0.335	0.45	0.439	0.492
Physical pain	-0.039	0.606	-0.506	0.376

Panel B: Gallup World Poll

Variable	Factor 1	Factor 2	Uniqueness
Sat. standard of living	-0.077	0.785	0.377
Life evaluation	-0.076	0.715	0.483
Satisfaction with city	-0.072	0.643	0.582
Enjoyment	-0.36	0.385	0.722
Stress	0.689	-0.03	0.524
Worry	0.713	-0.126	0.476
Sadness	0.704	-0.122	0.489
Anger	0.61	-0.068	0.623
Physical pain	0.489	-0.064	0.757

Table 5. Principal component factor analysis of physical pain, subjective wellbeing, and physical health among people without health problems. The Global Flourishing Study and the Gallup World Poll.
Note Results of principal-component factor analysis using GFS and GWP data. Table shows rotated factor loadings and unique variances. Bars show magnitude of factor loadings, coloured by positive or negative relationships (N Panel A = 146,102; N Panel B = 1,552,311).

of covariates as well as country and year fixed effects to account for potential confounding factors. These rigorous models led to a rather slight reduction in the estimates, underscoring the robustness and practical relevance of our findings.

Also across both datasets, we found that the correlation between physical pain and the current components of SWB was relatively low ranging from − 0.28 to 0.30. This suggests that the current components of SWB are not precise proxies for physical pain and that physical pain can capture aspects that the existing components of SWB may fail to address. In line with these results, prior work has demonstrated that physical pain is associated with given circumstances, like unemployment and other work arrangements, even after accounting for individuals' life satisfaction and mental health[23,25]. This research suggests that there is a pain effect that cannot be explained by the traditional components of SWB and capturing pain adds additional value to measuring the construct of SWB.

Based on these findings, we also explored whether, in principal component factor analysis, physical pain loads together with other components of negative affect. We found that, in the absence of health problems, physical pain and components of negative affect like stress, worry, sadness, and feeling anxious load primarily on the same factor. In the full sample, physical pain also loads on a factor that represents age-related physical health. These results suggest that pain is strongly linked to negative emotions, particularly, in the absence of health problems, thereby implying that pain is not exclusively a symptom of a physical health issue. One limitation of these factor analyses is that items that are negatively worded often load on the same factor. Thus, especially with the GFS data (Table 5, Panel A), the separate loadings on positive SWB and negative SWB, with pain loading on the latter, may arise in part from item wording. This may be somewhat less of a concern with the GWP data (Table 5, Panel B) as negative affect, positive affect, and physical pain have exactly the same wording "Did you experience the following feelings during a lot of the day yesterday? How about Enjoyment/Happiness/Stress/Worry/Anger/Sadness/Physical pain?"

Should physical pain be included in the conceptualization of subjective wellbeing used in the SWB literature? If so, how can this be done? The APA Dictionary of Psychology defines hedonics as "the branch of psychology

Fig. 2. Dimensions and components of subjective wellbeing.

concerned with the study of pleasant and unpleasant sensations and thoughts…"[33]. As physical pain involves an unpleasant sensation[34], it can be considered a hedonic experience. For instance, when people are asked about their level of physical pain with questions like "How much pain did you *feel* yesterday?" they need to rely on their hedonic experience (pleasant or unpleasant sensations) to provide an answer. Moreover, our findings show that physical pain and negative affect predominantly load on the same factor representing low subjective wellbeing. A tentative proposal based on the cumulative evidence of these results and the conceptual argument concerning the actual assessment of pain, is that physical pain be included in the hedonic dimension of SWB as a component of negative affect together with components like stress, worry, and sadness (Fig. 2).

Besides the results documented here, physical pain and the current components of SWB have additional critical features in common that support the inclusion of physical pain in the conceptualization of SWB. First, in line with the traditional components of SWB, physical pain is a human feeling that can be self-reported. Not only physicians value their patients' report of pain[11] but also a great number of large-scale datasets used in the SWB literature (e.g., The Gallup World Poll, Understanding Society) include questions about individuals' physical pain.

Second, as mentioned earlier, there is a strong parallelism between the empirical literature on SWB and the empirical work on physical pain. Recent research has shown that physical pain correlates with aspects that have been found to be linked to subjective wellbeing such as income, education, employment, the unemployment rate, volunteering time to an organisation, donating money to charity, and social connection. These common underlying aspects highlight the similarities between pain and other components of SWB (potentially due to the, albeit small, shared variance as shown in Fig. 1) as well as the importance of physical pain when assessing people's SWB.

Third, the components of subjective wellbeing have been used as measures of societal progress and wellbeing[2]. Recent research argues that pain should also be considered in this regard because it can complement the insights that existing components of SWB can provide[7].

In summary, this study provides evidence that people can experience negative affect-related pain in spite of their physical health status, without physical health problems, and when rating their physical health to be near perfect. We also document that the current components of SWB are not perfect proxies for pain and that physical pain and other components of negative affect like stress, worry, anxiety, anger, and sadness often load on the same underlying factor. As a result, our findings and argument suggest that physical pain can be included in the current conceptualization of SWB as a component of negative affect.

Ultimately, examining physical pain to understand how people feel can help researchers and policymakers to capture a better picture of individual's wellbeing. We hope that these results encourage future work on the socioeconomic, psychosocial, and behavioural aspects of physical pain and inform behavioural interventions and policymaking that aim to improve people's quality of life.

Methods
All analyses were preregistered with the Center for Open Science (COS) (https://osf.io/5z2v8/?view_only=1279 f804fdc040628645bfc35f87bacf). Preregistration can also be found in Text S.3 in the SM.

Data
In this study, we used two datasets: The Global Flourishing Study (GFS) and the Gallup World Poll (GWP).

The Global Flourishing Study (GFS) is a study of 202,898 participants from 22 geographically and culturally diverse countries concerning the distribution of determinants of wellbeing. GFS contains nationally representative samples from each country. Wave 1 of the data included the following countries and territories: Argentina, Australia, Brazil, Egypt, Germany, Hong Kong, India, Indonesia, Israel, Japan, Kenya, Mexico, Nigeria, the Philippines, Poland, South Africa, Spain, Sweden, Tanzania, Turkey, United Kingdom, and the United States. The countries were selected to (a) maximize coverage of the world's population, (b) ensure geographic, cultural, and religious diversity, and (c) prioritize feasibility and existing data collection infrastructure. Data collection was carried out by Gallup Inc. Data for Wave 1 were collected principally during 2023, with some countries beginning data collection in 2022 and exact dates varying by country[35]. Four additional waves of panel data on the participants will be collected annually from 2024 to 2027. The precise sampling design to ensure nationally representative samples varied by country and further details are available in Ritter et al.[35].

Survey items included aspects of wellbeing such as happiness, health, meaning, character, relationships, and financial stability, along with other demographic, social, economic, political, religious, personality, childhood, and community variables[36]. The data are publicly available through the Center for Open Science (COS, https://www.cos.io/gfs). During the translation process, Gallup adhered to the TRAPD model (translation, review, adjudication, pretesting, and documentation) for cross-cultural survey research (ccsg.isr.umich.edu/chapters/translation/overview). Additional details about methodology and survey development can be found in the GFS Questionnaire Development Report[37], and the GFS Methodology[35], GFS Codebook, and GFS Translations documents[38]. Based on availability of the relevant variables, the sample for our regression models consists of 187,160 individuals from 22 countries (47% male, s.d.= 0.499; Age: Mean = 45.813, s.d.= 17.558, Range = 18–99).

The Gallup World Poll is a nationally representative, cross-sectional dataset that includes data from 168 countries and territories from 2005 to 2024. Each year, Gallup conducts around 1,000 interviews in each country and gathers information about people's attitudes, beliefs, socioeconomic status, labour market circumstances, and health and wellbeing[39]. In regions where telephone coverage represents at least 80% of the population (Northern America, Western Europe, Confucian Asia and Pacific countries or territories including Japan, Australia, New Zealand and Taiwan, and Gulf Cooperation Council (GCC) countries) Gallup uses random-digit-dialling of a nationally representative list of telephone numbers. In regions with less extensive telephone coverage (Africa, Latin America, and some Middle east countries, Eastern Europe, and Southern Africa) surveys were administered face-to-face, and households were still randomly selected[40]. Based on availability of the relevant variables, the sample for our regression models consists of 2,048,494 individuals from 163 countries (46% male, s.d. = 0.499; Age: Mean = 41.8, s.d. = 17.887, Range = 15–100).

Using these two datasets (vs. only one) to address the same hypotheses provides a more comprehensive coverage of measures as one dataset complements the other. For example, both datasets have different pain questions, the GFS has measures like financial and material worry that the GWP does not provide, and the GWP includes components of subjective wellbeing like sadness, anger, worry, and stress that the GFS does not provide.

It is worth noting that the sample size varies across hypotheses due to availability of relevant variables. For instance, although the Gallup World Poll contains data from 2005 to 2024, key covariates like income and employment status are available from 2009. In addition, some components of subjective wellbeing like happiness, purpose, and job satisfaction cover some period in between the largest time span (e.g., 2005–2011, 2010–2013). Thus, due to lack of overlap among some variables and to preserve the largest sample across analyses, our regression models that control for income and employment status contain data from 2009 to 2024 (H1 and H2) whereas other analyses (H3, H4) use 2005–2024 data.

Measures
We used the following variables from the Global flourishing Study (GFS).

Dependent variable
Physical pain   Participants were asked "how much bodily pain have you had during the past 4 weeks? A lot, some, not very much, or none at all?" In our analyses, this variable signalled greater physical pain with a higher number (Mean = 2.336, s.d.= 0.956, Range = 1–4). In the regression models presented in the main text, this variable was used as continuous for ease of interpretation of the coefficients. This variable was also used as ordered categorical in the Ordered logistic regressions presented in the Supplementary Materials. Both methods produced substantively similar conclusions. This approach is supported by prior work that demonstrated that these two methods give similar results in this type of wellbeing analyses[41].

Independent variables
Feeling anxious   Participants were asked "over the last 2 weeks, how often have you been bothered by the following problems? Nearly every day (4), more than half the days (3), several days (2), or not at all (1)? Feeling nervous, anxious or on edge." This variable was used as continuous and signalled greater feelings of anxiety with a higher number (Mean = 1.917, s.d.= 0.980, Range = 1–4).

Feeling depressed   Participants were asked "over the last 2 weeks, how often have you been bothered by the following problems? Nearly every day (4), more than half the days (3), several days (2), or not at all (1)? Feeling down, depressed, or hopeless." This variable was used as continuous and signalled greater feelings of depression with a higher number (Mean = 1.805, s.d.= 0.960, Range = 1–4).

Traumatic distress   Participants were asked "think about the biggest threat to life you've ever witnessed or experienced first-hand during your life. In the past month, how much have you been bothered by this experience? A

lot (4), some (3), not very much (2), or not at all (1)?" This variable was used as continuous and signalled greater distress with a higher number (Mean = 2.081, s.d.= 1.012, Range = 1–4).

<u>Financial worry</u>   This measure was created combining two related variables: 1) Safety worry: "How often do you worry about safety, food, or housing? Please use a 0 to 10 scale where 10 means you do not ever worry and 0 means you worry all of the time" and Expenses worry: "How often do you worry about being able to meet normal monthly living expenses? Please use a 0 to 10 scale where 10 means you do not ever worry and 0 means you worry all of the time." Both measures were reverse coded to represent greater worry with a higher number. These two variables were summed and then averaged resulting in a measure of financial worry that ranges between 0 and 10 (Mean = 4.048, s.d.= 3.196) with high internal reliability (Cronbach's alpha 0.85).

Health covariates
<u>Health problems</u>   Participants were asked "do you have any health problems that prevent you from doing any of the things people your age normally can do?" and could answer yes (1) or no (0). In our sample, 21% of people reported to have physical health problems (s.d.= 0.407).

<u>Physical health</u>   Participants were asked "in general, how would you rate your PHYSICAL health? Please use a 0 to 10 scale where 10 means excellent physical health and 0 means poor physical health. You can use any number between 0 and 10." A higher number represented better physical health (Mean = 7.097, s.d.= 2.350).

Variables of subjective wellbeing
We used the following variables of subjective wellbeing available in the GFS to explore our hypotheses:

<u>Life satisfaction</u>   Participants were asked "Overall, how satisfied are you with life as a whole these days? Please use a 0 to 10 scale where 10 means completely satisfied with your life and 0 means not at all satisfied with your life" (Mean = 6.875, s.d.= 2.571).

<u>Life evaluation</u>   Participants were asked "Please imagine a ladder with steps numbered from zero at the bottom to ten at the top. Suppose we say that the top of the ladder represents the best possible life for you, and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time?" (Mean = 6.499, s.d.= 2.443).

<u>Purpose in life</u>   Participants were asked "Still thinking about the ladder, with the top of the ladder at ten being strongly agree and the bottom of the ladder at zero being strongly disagree, please rate your level of agreement with the following statements. You understand your purpose in life." (Mean = 7.471, s.d.= 2.548).

<u>Meaning in life</u>   Participants were asked "Overall, to what extent do you feel the things you do in your life are worthwhile? Please use a 0 to 10 scale where 10 means completely worthwhile and 0 means not at all worthwhile." (Mean = 7.349, s.d.= 2.441).

<u>Happiness</u>   Participants were asked "In general, how happy or unhappy do you usually feel? Please use a 0 to 10 scale where 10 means extremely happy and 0 means extremely unhappy" (Mean = 7.041, s.d.= 2.341).
   We used the following variables from the Gallup World Poll (GWP).

Dependent variable
<u>Physical pain</u>   Participants were asked to "…please think about yesterday, from the morning until the end of the day. Think about where you were, what you were doing, who you were with, and how you felt." They were then asked "Did you experience the following feelings during a lot of the day yesterday? How about … Physical Pain?" and could answer yes (1) or no (0). In our sample, 31% of people experienced physical pain the day before (s.d.= 0.463). Following prior work[23], in the regression models presented in the main text, this variable was used as continuous for ease of interpretation of the coefficients. This variable was also used as binary with 'no' as the reference category in the Binary logistic regressions presented in the Supplementary Materials. Both methods yielded the same results.

Independent variables
<u>Negative affect</u>   The measures of negative affect available in the GWP used the same structure as the pain question. Participants were asked "Did you experience the following feelings during a lot of the day yesterday? How about … Sadness/anger/stress/worry" and could answer yes (1) or no (0). In our sample, 23.7% of people experienced sadness (s.d.= 0.425), 19.9% anger (s.d.= 0.400), 33.5% stress (s.d.= 0.472), and 38.1% worry (s.d.= 0.486) the day before.

Health covariates
<u>Health problems</u>   Participants were asked "do you have any health problems that prevent you from doing any of the things people your age normally can do?" and could answer yes (1) or no (0). In our sample, 24.7% of people reported to have physical health problems (s.d.= 0.431). In the regression models, this variable was used as binary with 'no' as the reference category.

<u>Health near perfect</u>   Participants were asked "thinking about your life in general, please rate your level of agreement with each of the following using a five-point scale, where 5 means you STRONGLY AGREE and 1

means you STRONGLY DISAGREE. You may choose any of the numbers 1, 2, 3, 4, or 5. Your physical health is near-perfect." This measure was available only from 2013 to 2016. This variable was included as continuous in our analyses with higher numbers representing agreement with the statement "my physical health is near-perfect" (Mean = 3.646, s.d. = 1.232).

Variables of subjective wellbeing
We used the following variables of subjective wellbeing available in the GWP to explore our hypotheses:

Life evaluation   Participants were asked "Please imagine a ladder with steps numbered from zero at the bottom to ten at the top. Suppose we say that the top of the ladder represents the best possible life for you, and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time, assuming that the higher the step the better you feel about your life, and the lower the step the worse you feel about it? Which step comes closest to the way you feel?" (Mean = 5.557, s.d. = 2.421).

Purpose in life   Participants were asked "Do you feel your life has an important purpose or meaning?" and could answer yes or no. 92.8% of people reported that they felt that their life had important purpose or meaning (s.d. = 0.259).

Happiness   Participants were asked "Did you experience the following feelings during a lot of the day yesterday? How about Happiness?" and could answer yes or no. 71.5% of people experienced happiness the day before (s.d. = 0.451).

Enjoyment   Participants were asked "Did you experience the following feelings during a lot of the day yesterday? How about Enjoyment?" and could answer yes or no. 70.3% of people experienced enjoyment the day before (s.d. = 0.457).

Job satisfaction   Participants were asked "Are you satisfied or dissatisfied with your job or the work you do?" and could answer satisfied (1) or dissatisfied (0; Mean = 0.783, s.d. = 0.412).

Satisfaction with standard of living   Participants were asked "Are you satisfied or dissatisfied with your standard of living, all the things you can buy and do?" and could answer satisfied (1) or dissatisfied (0; Mean = 0.641, s.d. = 0.480).

Satisfaction with health   Participants were asked "Are you satisfied or dissatisfied with your personal health?" and could answer satisfied (1) or dissatisfied (0; Mean = 0.785, s.d. = 0.411).

Satisfaction with City   Participants were asked "Are you satisfied or dissatisfied with the city or area where you live?" and could answer satisfied (1) or dissatisfied (0; Mean = 0.793, s.d. = 0.406).

Demographic characteristics
We also used the following covariates which were available in *both datasets*.

Age   In both datasets this variable represented participant's age.

Gender   In both datasets this variable represented participant's gender.

Education   Participant's education was assessed with the following categories in the GWP: elementary, secondary, tertiary, and with the following categories in the GFS: up to 8 years, 9–15 years, and 16 + years.

Marital status   Participant's marital status was assessed with the following categories in the GWP: single/never married, domestic partner, married, separated, divorced, widowed, and with the following categories in the GFS: married, separated, divorced, widowed, never married, and domestic partner.

Employment status   Participant's employment status was assessed with the following categories in the GWP: employed full-time for an employer, employed full-time for self, employed part-time want full-time, employed part-time do not want full-time, unemployed, out of labour force, and with the following categories in the GFS: employed for an employer, self-employed, retired, student, homemaker, unemployed and looking for a job, and none of these/other.

Income   In the GWP, participants were asked "what is your total monthly household income, before taxes? Please include income from wages and salaries, remittances from family members living elsewhere, farming, and all other sources." Income was expressed in local currency and Gallup created a measure of household annual income in International Dollars. To obtain this final variable, Gallup converted the original measure to International Dollars using the World Bank's individual consumption PPP conversion factor, making income estimates comparable across all countries. As income was comparable across all countries, this measure was used as continuous in our analyses.

In the GFS, participants were asked "what is your total monthly household income in [country currency], before taxes? Please include income from wages and salaries, remittances from family" and could place themselves in a category that represented a range of income in their own currency. Given that categories included different

ranges (vs. absolute values) across countries, original categories were preserved, and the resulting variable was included as categorical in the list of covariates. Means and standard deviations of each category can be found in the Supplementary Materials.

Number of children in the household   In the GWP, participants were asked "how many children under 15 years of age are now living in your household?" In the GFS, participants were asked "How many children under 18 years of age are now living in your household?" In both cases, participants could answer any number.

Descriptive statistics for the variables used in the analyses can be found in Tables S1 and S2 in the Supplementary Materials.

Statistical analyses

To explore Hypothesis 1 and 2, we used unweighted Ordinary Least Squares (OLS) regressions with physical pain as the dependent variable. We also conducted robustness checks with Binary logistic regressions with the binary pain variable from the GWP and Ordered logistic regressions with the ordered categorical pain variable from the GFS. These choices are supported by prior work that showed that assuming cardinality or ordinality of wellbeing variables and using various methods lead to the same conclusions[41]. Indeed, all methods produced substantively similar conclusions which can be found in the Supplementary Materials.

Hypothesis 1 proposed that there will be a significantly positive association between negative affect and physical pain after controlling for physical health. Thus, we conducted regressions with physical pain as the dependent variable, different measures of negative affect as the main independent variable, and demographic characteristics. All our models controlled for physical health to rule out the possibility that physical pain was only a proxy for physical health. The variables of negative affect and physical health varied across the two datasets (see above). The regressions conducted with the GWP included country and year fixed effects while the regressions conducted with the GFS included country fixed effects (the GFS contains data from 22 countries but only one survey year). This is to account for the common factors across countries and survey years that might affect the relationship of interest.

Hypothesis 2 proposed that there will be a significantly positive association between negative affect and physical pain among people who did not have health problems and those who reported that their physical health was near perfect. Thus, we created four subsets: (1) participants who had physical health problems, (2) participants who did not have physical health problems, (3) participants who reported that their physical health was near perfect (4 and 5 in the 1–5 scale), and (4) participants who reported that their physical health was not near perfect (1 and 2 in the 1–5 scale). We also conducted sensitivity analyses with participants who reported 5 in the near perfect health question. We then conducted the regressions with physical pain as the dependent variable, negative affect as the main independent variable, and demographic characteristics as covariates across these four subsets. As in H1, the regressions conducted with the GWP included country and year fixed effects while the regressions conducted with the GFS included country fixed effects. It is worth noting that the use of an interaction term between negative affect and the physical health variables did not meet the objective of the test which was to explore whether negative-affect related pain exists among people without physical health problems.

To examine Hypothesis 3 which proposed that the existing components of subjective wellbeing will not be highly correlated with physical pain, we conducted Pearson correlations between physical pain and different components of SWB. The GFS includes negative affect (feeling anxious, feeling depressed, financial worry), evaluative wellbeing (life satisfaction, life evaluation), positive affect (happiness), and fulfilment (meaning, purpose). Given that correlations did not include covariates, our final sample size for these tests using the GFS was 197,839. The GWP contains the following variables of SWB: negative affect (sadness, anger, stress, worry), evaluative wellbeing (life evaluation), fulfilment (purpose in life), positive affect (enjoyment, happiness), domain satisfaction (job satisfaction, satisfaction with city, satisfaction with health, satisfaction with standard of living). Given that these correlations did not use the covariates that were available only from 2009, the correlations conducted with the GWP used data from 2005 to 2024 (see Fig. 1 for more details and sample size for each variable). Across the two datasets, we examined the correlation between physical pain and the available measures of SWB.

We conducted an additional exploratory analysis. Hypothesis 4 proposed that physical pain and negative affect will load on the same underlying factor. To examine this hypothesis we conducted principal component factor analysis with physical pain, variables of subjective wellbeing, and physical health. We also conducted sensitivity analyses including age which is a key demographic characteristic strongly related to physical pain and physical health. Following the regression models, we conducted these analyses in the full sample and in the subsample of people without health problems. We standardized all the variables to be continuous with mean of 0 and standard deviation of 1 and used orthogonal varimax rotation to ease interpretation of results[42]. We also used scree plots to select the number of factors to use based on the size of the eigenvalues. These graphs for all samples can be found in Figure S1 to S4 in the SM. To maximize sample size in the GWP, we used the variables that were available in the full time span (2005–2024) and left out the variables that were only available in a smaller time span like happiness (2008–2013). However, the role of these variables was captured in the GFS data. Given that GFS only contains one year of data, all relevant variables were included in the principal component factor analysis.

Data availability

The Global Flourishing Study data are publicly available through the Center for Open Science (https://www.cos.io/gfs). The Gallup World Poll data belong to Gallup, Inc. For more information, see: https://www.gallup.com/analytics/318875/global-research.aspx. All analyses were preregistered with the Center for Open Science (COS) (

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Author contributions

L.M. Designed the research, conducted the data analysis, and wrote the paper. M.K. Contributed to the data analysis and provided comments to the written drafts. B.R.J. Coordinated data collection of GFS and provided comments to the written draft.T.J.V. Coordinated data collection of GFS and provided comments to the written draft.

Declarations

Competing interests
The authors declare no competing interests.

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