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Psychological Capital and Emotion Regulation Among Middle-Aged and Older Adults in Sports Clubs: A Network Analysis

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Abstract

Background: China's population ageing increases the need to understand psychological resources that support adaptive functioning. Psychological capital (PsyCap) and emotion regulation (ER) are usually examined as aggregate constructs, obscuring their component-level organization and cross-domain pathways. Grounded in Conservation of Resources (COR) theory, this study mapped the dimension- and item-level networks linking PsyCap and ER among middle-aged and older sports club members, identified central and bridge nodes, and explored potential directional pathways. This component-level perspective clarifies how these resources may jointly sustain sport participation and well-being in later life.

Methods: A total of 4,973 sports club members from 20 regions of China completed the Positive Psychological Capital Questionnaire and Emotion Regulation Questionnaire. Gaussian graphical models were estimated at the dimension and item

25 levels. Expected influence, strength, and bridge expected influence identified
26 influential nodes; bootstrap analyses assessed network accuracy and stability; and
27 exploratory directed acyclic graph (DAG) modeling examined hierarchical pathways.

28 **Results:** Positive associations predominated in both networks. At the dimension level,
29 optimism had the highest expected influence, hope had the highest strength, and the
30 hope-optimism association was the strongest. PC-H19 and PC-O24 were key
31 item-level nodes. Cognitive reappraisal was the principal bridge between PsyCap and
32 ER, connecting positively with all PsyCap dimensions and showing the highest bridge
33 expected influence; ER-C1, ER-C5, and ER-C3 were the most influential bridge items.
34 Expressive suppression displayed weaker and more heterogeneous associations: its
35 links with core PsyCap resources were predominantly negative, whereas its
36 connection with resilience was positive. The exploratory DAG placed resilience
37 upstream, optimism, hope, and self-efficacy in intermediate positions, and ER
38 strategies downstream.

39 **Conclusion:** This is the first network study of these interconnections in this
40 population. PsyCap and ER appear to form an integrated, hierarchically organized
41 resource system rather than isolated constructs. Optimism and hope were central
42 resources, cognitive reappraisal was the main cross-domain bridge, and resilience may
43 provide an upstream foundation supporting regulatory processes through other
44 PsyCap components. These findings extend the application of COR theory and may
45 inform future psychological interventions for middle-aged and older adults.

46 **Keywords:** Psychological capital (PsyCap), Emotion regulation, Middle-aged and
47 older adults, network analysis, Physical activity

49 **Introduction**

50 Global population ageing is accelerating, bringing increasing attention to how
51 additional years of life can be lived with health, autonomy, and psychological
52 well-being. The World Health Organization [1] estimates that the global population
53 aged 60 years and older will increase from 1.0 billion in 2020 to 1.4 billion by 2030
54 and 2.1 billion by 2050. Yet longevity alone does not constitute healthy ageing. The
55 WHO defines healthy ageing as the process of developing and maintaining the
56 functional ability that enables well-being in older age, emphasizing the interaction
57 between individuals' intrinsic capacities and the environments in which they live [2].
58 This perspective is especially relevant because later life often entails declines in
59 physical and mental capacity, chronic health conditions, retirement, bereavement, and
60 changes in social roles and relationships [3], which in turn heighten the risk of mental
61 health problems such as anxiety, depression, and loneliness [4]. Such transitions do
62 not inevitably result in poor psychological outcomes, but they can increase the
63 demands placed on older adults' capacity to adapt. Accordingly, identifying
64 psychological resources that help older adults respond to age-related challenges,
65 remain socially engaged, and sustain well-being represents an important component
66 of the healthy-ageing agenda.

67 Against this background, increasing attention has been directed toward positive
68 psychological resources that may support adaptation and well-being in later life.
69 Rather than focusing solely on psychological deficits or mental health problems,
70 positive aging research emphasizes psychological strengths and capacities that enable

71 older adults to cope with age-related challenges and maintain adaptive functioning
72 [5,6]. Evidence further suggests that different positive psychological resources may
73 contribute to positive adaptation in later life. For example, optimism, self-efficacy,
74 and self-esteem have been associated with subjective well-being among older adults
75 [7], while optimism, and mastery have also been examined as important personal
76 resources related to health in later life [8]. In addition, resilience has been identified as
77 an important capacity for coping with adversity and maintaining positive
78 psychological functioning [9]. Collectively, these findings underscore the broader
79 importance of positive psychological resources for mental health, well-being, and
80 adaptive functioning in aging populations.

81 PsyCap provides a particularly relevant framework for examining such positive
82 resources. PsyCap is commonly conceptualized as a developable, state-like
83 higher-order construct comprising self-efficacy, hope, optimism, and resilience [10].
84 Collectively, these dimensions reflect confidence in mobilizing effort, the capacity to
85 generate and redirect pathways toward goals, positive expectations about future
86 outcomes, and the ability to recover and adapt following adversity. Although PsyCap
87 was originally conceptualized within organizational psychology, growing evidence
88 highlights its significance in later life across diverse cultural contexts. Evidence from
89 multiple populations further underscores the relevance of PsyCap and its core
90 psychological resources in supporting health and adaptation in older adulthood. In
91 Europe, studies among Greek older adults demonstrated that individuals with high
92 PsyCap were better able to buffer the detrimental effects of negative self-perceived

93 ageism and to amplify the benefits of positive ageism on quality of life [11].

94 Similarly, research with Romanian retirees showed that compound PsyCap fully

95 mediated the relationship between perceived social support and health-related quality

96 of life, with hope, optimism, and self-efficacy particularly predictive of mental health

97 outcomes [12]. In the Americas, research among Mexican older adults supported a

98 second-order PsyCap structure integrating optimism, resilience, hope, and

99 self-efficacy; PsyCap and each of its four dimensions were also negatively associated

100 with depression [13]. In China, evidence among older adults confirmed that PsyCap

101 was positively associated with subjective well-being, operating through multiple

102 mediating pathways such as subjective socioeconomic status, justice perceptions, and

103 marital satisfaction [14]. Moreover, large-scale research on Chinese middle-aged and

104 elderly square-dance participants showed that PsyCap was significantly enhanced

105 through structured physical activity, with cognitive reappraisal and prosocial behavior

106 serving as mediating mechanisms, thereby underscoring the role of organized exercise

107 in strengthening psychological resilience and social well-being [15]. Collectively,

108 these findings underscore the importance of PsyCap-related resources for health and

109 adaptive functioning in later life. At the same time, they indicate that PsyCap is

110 relevant to positive adaptation across cultural contexts, while its configuration and

111 salience may vary with cultural and life-stage conditions-highlighting the need to

112 examine how conventional PsyCap dimensions operate within specific older

113 populations rather than assuming uniformity across settings.

Psychological resources alone, however, do not fully explain how older adults respond to emotionally demanding situations. Adaptation also depends on emotion regulation, referring to the processes through which individuals influence the occurrence, experience, and expression of emotion. Within Gross's process model, cognitive reappraisal and expressive suppression represent two widely studied strategies that operate at different points in the emotion-generative process [16]. Cognitive reappraisal involves changing the interpretation of an emotion-eliciting situation before the emotional response is fully developed and is generally associated with more favorable affective and well-being outcomes [17]. In older adults, positive reappraisal has been identified as a particularly relevant coping process for deriving meaning from adverse experiences and managing illness-related or other later-life stressors [18]. Expressive suppression, by contrast, involves inhibiting the outward expression of an already-generated emotional response. Habitual suppression has often been associated with lower positive affect and poorer well-being, and experimental research indicates that suppressing emotional expression can impose cognitive costs, including impaired memory for emotional events [19,20]. Nevertheless, suppression is not necessarily uniformly maladaptive because its interpersonal meaning and consequences can vary across cultural and situational contexts. Conceptually, ER should therefore not be treated simply as another positive psychological resource. Rather, it may be better understood as a set of regulatory processes through which available psychological resources are mobilized, preserved, redirected, or expended when individuals encounter emotionally salient demands.

136 The relationship between PsyCap and emotion regulation may become especially
137 salient within organized sports clubs. Unlike solitary physical activity, sports clubs
138 are recurring social environments in which older adults pursue shared goals,
139 experience mastery and setbacks, interact with peers, negotiate performance
140 differences, and develop belonging and mutual support. Evidence from group-based
141 physical activity research indicates that sport or exercise group membership can carry
142 psychological benefits that extend beyond physical activity itself, partly through the
143 social identities and support generated by group participation [21]. Critically, emotion
144 regulation in such collective settings operates beyond individual and interpersonal
145 levels. Goldenberg and Cao [22] conceptualized collective emotion regulation as a
146 macro-level process whereby group members actively shape the collective emotional
147 climate via situational, network, and cognitive strategies-a framework directly
148 pertinent to sports clubs, where shared rituals, peer modeling, and informal leadership
149 modulate how emotions are co-constructed and managed. Concurrently, club
150 participation entails evaluation, competition, disagreements, role expectations, and
151 relational concerns, necessitating recurrent ER. Higher PsyCap may enable older
152 adults to reframe setbacks and interpersonal tensions more constructively, while the
153 ER strategies deployed reciprocally influence whether psychological resources are
154 maintained or depleted. Cross-cultural research has shown that habitual suppression
155 was positively related to viewing interpersonal harmony as an important social goal
156 among Chinese participants, but not to the same extent among European Americans
157 [23]. Thus, expressive suppression in a Chinese group setting should not be assumed a

priori to be purely dysfunctional. Sports clubs consequently serve as a meaningful context to explore how these psychological resources and regulation strategies dynamically interact during late-life social engagement.

Conservation of Resources (COR) theory offers a coherent framework for integrating these processes. Originally proposed as a stress model, COR theory posits that individuals strive to acquire, maintain, and protect valued resources, and stress arises when resources are threatened, lost, or fail to yield expected returns [24,25]. Resources are multidimensional, encompassing material (e.g., financial security), energy (e.g., health, time, cognitive capacity), personal characteristics (e.g., self-efficacy, optimism, resilience, hope), and social resources (e.g., support, belonging) [26]. In the context of sports clubs, material and energy resources provide the essential prerequisites for participation, while the club environment supplies social resources through peer support and group belonging [27]. PsyCap represents a core personal resource reserve, and emotion regulation strategies—specifically cognitive reappraisal and expressive suppression—shape how these resources are invested, conserved, or depleted. COR theory further emphasizes "resource caravans," whereby initial resource gains foster additional accumulation, while resource loss increases systemic vulnerability. Within sports clubs, mastery experiences and peer encouragement can initiate gain spirals that strengthen PsyCap and adaptive regulation, whereas sustained expressive suppression may preserve social harmony at the expense of personal energy [20,28,29]. Thus, sports clubs function as dynamic

resource ecosystems, where PsyCap and emotion regulation dynamically interact to determine trajectories of resource gain or loss in later life.

Network analysis provides a complementary approach by modeling psychological components as nodes and their unique associations as edges, allowing researchers to examine the architecture of interrelations rather than treating constructs as internally homogeneous [30]. This method identifies central nodes with strong influence, bridge nodes linking distinct domains, and the overall clustering structure of the system [31]. In ageing research, network analysis has revealed how positive resources interact dynamically. Thoma et al. [32] found exclusively positive interrelations among resilience resources in older adults, whereas current stress weakened these connections, indicating that resource functioning depends on configuration and context. Brinkhof et al. [3] showed that quality of life was most directly related to positive appraisal and self-management ability, with self-efficacy occupying a central position; physical activity was embedded within this broader resilience-resource system. A subsequent study further showed that mental well-being and quality of life were embedded in a multifactorial network, with positive appraisal, self-management, and social support emerging as central protective factors, whereas loneliness, depression, poor sleep, and negative self-perceptions of ageing represented key risk factors [33]. Most relevant to the present study, Guo et al. [34] examined networks linking affect, emotion regulation, and PsyCap among Chinese men, finding cognitive reappraisal positively connected with optimism and self-efficacy and functioning as a key bridge node. However, that study did not include older adults or

201 in sport context. Collectively, these findings demonstrate that network analysis can
202 reveal which psychological components are central, which bridge distinct domains,
203 and how their interconnections shape positive adaptation in later life.

204 Despite these advances, several gaps remain. First, PsyCap and emotion
205 regulation are still commonly modeled as aggregate constructs [17,10], leaving the
206 fine-grained architecture linking self-efficacy, hope, optimism, resilience, cognitive
207 reappraisal, and expressive suppression insufficiently understood. Consequently, it
208 remains unclear whether particular PsyCap components occupy disproportionately
209 important positions or whether specific emotion regulation components bridge distinct
210 domains. Second, network studies in older adults have primarily centered on
211 resilience resources, quality of life, stress, or affective status (e.g., depression,
212 anxiety), as well as broader successful-ageing systems [35,36], rather than addressing
213 the interconnections among psychological resources and regulatory processes. Third,
214 little is known about how these relationships operate among older adults in organized
215 sports clubs-a context that integrates goal pursuit, physical engagement, social
216 interaction, and emotionally meaningful group demands [18]. Finally, although COR
217 theory offers a strong rationale for viewing psychological resources as interdependent,
218 the component-level configuration linking PsyCap with regulatory processes has
219 rarely been mapped empirically in older adults.

220 Therefore, based on the COR theory, this study aims to employ network analyses
221 to examine the interrelationships between PsyCap and emotion regulation among
222 older adults in organized sports clubs.

RQ1. What are the dimension-level and item-level network structures connecting PsyCap and emotion regulation among older sports club members, and do these networks exhibit cross-level structural consistency?

RQ2. Which PsyCap dimensions, emotion regulation strategies, and individual items occupy the most central positions within these networks, as indicated by node centrality and expected influence

RQ3. Which dimensions or items function as key bridge nodes connecting the PsyCap and emotion-regulation domains, as indicated by bridge expected influence and cross-domain connectivity?

RQ4. How do cognitive reappraisal and expressive suppression differ in the pattern, direction, and strength of their connections with PsyCap across both dimensional and item levels?

RQ5. Which PsyCap and emotion regulation components occupy upstream versus downstream positions within the directional structure suggested by exploratory DAG analysis?

Method

Study design and participants

This study employed a cross-sectional survey design to recruit middle-aged and older adults in sport clubs across China. Using convenience sampling, the survey was administered across 52 sports organizations in 20 provincial-level administrative regions. All participants were informed of the relevant information prior to

completing the questionnaire and participated voluntarily. Data were collected via the Questionnaire Star platform (<https://www.wjx.cn/>), with a total of 5,515 initial responses received. Given the self-reported nature of the data, a rigorous quality control procedure was implemented to minimize the influence of response bias and input errors. Using SPSS version 27.0, questionnaires were excluded if they met any of the following criteria [37,38,39]: (1) an average response time of less than 2 seconds per item; (2) missing responses to any questionnaire items; (3) failure to meet the age requirement (i.e., younger than 55 years); (4) identical responses to more than 70% of items; or (5) failure to pass the embedded attention-check items. Following this screening procedure, 4,973 valid questionnaires were retained, yielding a valid response rate of 90.17%.

The final analytical sample comprised 4,973 participants, ranging in age from 55 to 89 years, with a mean age of 59.14 years ($SD = 7.17$). Of these, 213 (4.28%) were male and 4,760 (95.72%) were female. According to the requirements of sports associations (i.e., no less than four times a week and a single-session duration of at least 60 min), it was necessary to ensure that the middle-aged and older adults who were eligible for this study had accumulated a moderate or large amount of PA in the previous month [40]. The study protocol was approved by the Sports Science Experiment Ethics Committee of Beijing Sport University (Approval No.: 202305H), and all participants provided written informed consent prior to enrollment. All procedures were conducted in accordance with relevant ethical guidelines and regulations.

Measures

Psychological capital

Participants' psychological capital was assessed using the Positive Psychological Capital Questionnaire (PPQ), adapted from Zhang [41]. The questionnaire consists of 26 items across four dimensions: self-efficacy (7 items), resilience (7 items), hope (6 items), and optimism (6 items). All items are rated on a 7-point Likert scale ranging from 1 ("strongly disagree") to 7 ("strongly agree"), with several items being reverse-scored. Higher scores indicate higher levels of psychological capital. Previous research has demonstrated that the PPQ has good reliability and structural validity in Chinese populations [41,42]. In the present study, the overall Cronbach's α of the scale was 0.912.

Emotion regulation

The Emotion Regulation Questionnaire (ERQ) was used to assess participants' emotion regulation strategies. The questionnaire consists of 10 items across two dimensions: cognitive reappraisal (6 items) and expressive suppression (4 items). All items are rated on a 7-point Likert scale ranging from 1 ("strongly disagree") to 7 ("strongly agree"). Higher scores on each dimension indicate a greater tendency to use the corresponding emotion regulation strategy. Previous research has demonstrated that the ERQ has good reliability and supported its two-factor structure [19]. In this study, the Cronbach's α of the scale was 0.893.

Physical activity level

Physical activity level was assessed using the Physical Activity Rating Scale-3 (PARS-3), originally developed by Hashimoto [43] and later translated and revised by Liang [44]. The instrument comprises three items evaluating intensity (1–5), duration (0–4), and frequency (1–5) of activity during the past month. A composite score was calculated as $PA = \text{intensity} \times \text{duration} \times \text{frequency}$, yielding a range from 0 to 100, with higher scores indicating greater activity. Consistent with established cutoffs, scores were categorized as low (0–19), moderate (20–42), and high (≥ 43). The PARS-3 has demonstrated acceptable reliability (Cronbach's $\alpha = 0.82$; test–retest reliability = 0.91). Importantly, in the present study this measure was used solely to screen and classify older adults who met the criteria for sports club participation, rather than to evaluate other outcomes.

Statistical analysis

Data management, descriptive statistical analyses, and reliability analyses were performed using SPSS version 27.0. Network analyses were conducted in R (version 4.5.2.). The “bootnet” package was used for network estimation and bootstrap analyses of network accuracy and stability, the “qgraph” package was used for network visualization and centrality analysis, and the “networktools” package was used to calculate expected influence (EI). The “ggplot2” package was used to visualize centrality indices, and the “bnlearn” package was used for the directed acyclic graph (DAG) analysis. The analyses included network estimation, node centrality analysis, assessments of network accuracy and stability, and exploratory DAG analysis.

Network estimation

Gaussian graphical models (GGMs) were used to construct a six-node dimension-level network and a 36-node item-level network of PsyCap and emotion regulation [45]. GGMs estimate conditional associations between nodes while controlling for all other nodes in the network [46]. For each network, correlations among nodes were first estimated using the `cor auto` procedure. The resulting correlation matrix was then subjected to graphical least absolute shrinkage and selection operator (LASSO) regularization, and the Extended Bayesian Information Criterion (EBIC) was used to select the optimal network structure. The EBIC tuning parameter (γ) was set to 0.50 [47]. Through this procedure, relatively weak associations were shrunk toward zero, resulting in a sparse network that retained the more robust relationships among nodes. In the final network, edges represented regularized partial correlations between nodes. Green and red edges indicated positive and negative associations, respectively, and thicker edges represented stronger associations.

Network characterization

Node importance was evaluated using four centrality indices: strength, closeness, betweenness, and expected influence (EI). Previous methodological studies have noted potential limitations in the stability of closeness and betweenness, whereas strength mainly reflects the magnitude of a node's direct connections [48,49]. EI was calculated as the sum of the weights of all edges connected to a node while retaining their original signs. Previous studies have suggested that nodes with higher EI values

tend to exert greater influence within the network [48]. Therefore, EI was used as the primary indicator for identifying core nodes in the network.

Bridge expected influence

To identify nodes that played important roles in connecting the PsyCap and emotion regulation communities, bridge expected influence (BEI) was calculated. Nodes were assigned to two predefined communities: PsyCap and ER. BEI was defined as the signed sum of the edge weights connecting a given node to nodes in the other community, excluding within-community connections [31]. Because the estimated networks contained both positive and negative edges, BEI was used to retain the direction of cross-community associations, with higher positive values indicating stronger net positive connectivity and negative values indicating predominantly negative cross-community connectivity [31]. BEI was calculated at both the dimension and item levels. Its stability was further evaluated using case-dropping bootstrap procedures and quantified using the correlation stability coefficient [30].

Network accuracy and stability

Network accuracy and stability were assessed using the “bootnet” package with 1000 bootstrap resamples. Edge-weight accuracy was evaluated using nonparametric bootstrap 95% confidence intervals (CIs), with narrower CIs indicating estimation accuracy. Centrality stability was assessed using case-dropping bootstrap procedures and quantified using the correlation stability coefficient (CS-coefficient). CS-coefficients should not be below 0.25 and are preferably above 0.50 [30].

DAG Analysis

To address the limitation of partial correlation models in predicting the potential direction of influence among nodes, a DAG was constructed to further explore potential directional relationships between PsyCap and emotion regulation. The DAG was estimated using the “bnlearn” package in R. The network structure was first learned using the hill-climbing algorithm, with the Gaussian Bayesian Information Criterion used to select the optimal structure [50]. The analysis was then repeated across 1,000 bootstrap samples to evaluate the reproducibility of the connections and their directions. A bootstrap-averaged DAG was subsequently constructed by retaining connections that exceeded the data-derived arc-strength threshold, and directional support was calculated for each retained connection. In the final DAG, arrowheads indicated the retained directions, while thicker lines represented greater directional support.

Results

Network structure

To understand the correlation patterns between PsyCap and emotion regulation more clearly, and to identify relatively important variables, we constructed a network model and estimated both the dimensional and item networks of PsyCap and emotion regulation, with descriptions of each node provided in Table 1.

Table 1. Basic characteristics of the nodes in the item network

Notes: *M* = mean; *D* = standard deviation; (*) = reverse-scored item.

374 The Dimension level network comprised six nodes: self-efficacy (PC-S),
375 resilience (PC-R), hope (PC-H), optimism (PC-O), cognitive reappraisal (ER-C), and
376 expressive suppression (ER-E). Following EBIC glasso regularization, 14 of the 15
377 possible edges were retained, including 10 positive and 4 negative edges, with a
378 global network strength of 2.899. As shown in Fig 1A, the strongest positive edge was
379 observed between PC-H and PC-O ($r = 0.553$), followed by PC-S and PC-H ($r =$
380 0.369), PC-O and ER-C ($r = 0.311$), and PC-S and PC-R ($r = 0.298$). The strongest
381 negative edge was observed between PC-R and PC-H ($r = -0.289$). ER-C was
382 positively associated with all four PsyCap dimensions, with the strongest association
383 observed with PC-O ($r = 0.311$), followed by PC-S ($r = 0.150$), PC-H ($r = 0.125$), and
384 PC-R ($r = 0.029$). ER-E was positively associated with PC-R ($r = 0.206$) but
385 negatively associated with PC-S ($r = -0.127$), PC-H ($r = -0.035$), and PC-O ($r =$
386 -0.017). No edge was retained between ER-C and ER-E.

387 The item level network comprised 36 nodes representing 26 PsyCap items and
388 10 ER items. Following regularization, 302 nonzero edges were retained, including
389 248 positive and 54 negative edges, with a global network strength of 19.044. As
390 shown in Fig 1B, the strongest edge was observed between PC-S1 and PC-S3 ($r =$
391 0.442), followed by PC-H17 and PC-H19 ($r = 0.407$), ER-E6 and ER-E9 ($r = 0.402$),
392 ER-C7 and ER-C8 ($r = 0.351$), and PC-O20 and PC-O24 ($r = 0.344$). Among the
393 PsyCap and ER connections, the largest negative edges were observed between
394 PC-H25 and ER-E6 ($r = -0.096$) and between PC-H25 and ER-E4 ($r = -0.081$). The
395 largest positive edges were observed between PC-R6 and ER-C3 ($r = 0.073$), PC-S9

and ER-C5 ($r = 0.072$), and PC-O24 and ER-C1 ($r = 0.064$). Collectively, the item-level cross-construct connections closely mirrored the pattern observed in the dimension-level network, demonstrating robust cross-level structural consistency: cognitive reappraisal consistently exhibited positive couplings with PsyCap across both levels, whereas expressive suppression displayed distinct negative associations with key psychological resources, particularly hope and self-efficacy.

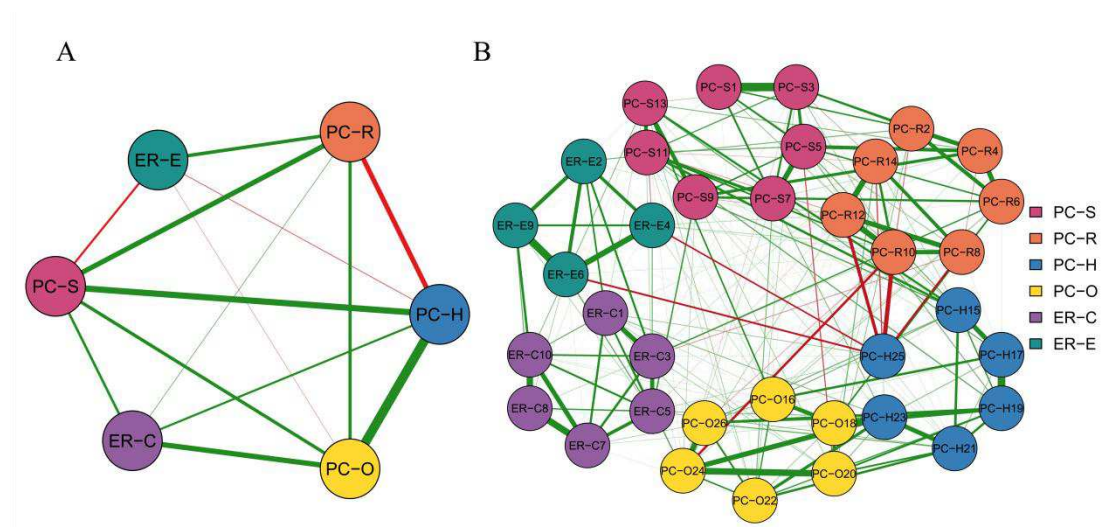


Fig. 1 Dimension level and item level networks of PsyCap and emotion regulation.

Notes: Panel A represents the dimension level network and Panel B represents the item level network. Nodes represent dimensions or individual items of PsyCap and emotion regulation. Edges represent regularized partial correlations between nodes. Green edges indicate positive associations, whereas red edges indicate negative associations. Edge thickness is proportional to the absolute magnitude of the edge weight.

Centrality measure analysis

Expected influence

The expected influence (EI) indices of the dimension level and item level networks are presented in Fig 2. At the dimension level, PC-O had the highest EI (1.236), followed by PC-S (0.888), PC-H (0.724), ER-C (0.616), and PC-R (0.435). ER-E had the lowest EI (0.026). At the item level, PC-H19 had the highest EI (1.332), followed by PC-H23 (1.158), ER-C7 (1.109), PC-S5 (1.083), and PC-H15 (1.072).

416 PC-S7 (1.050), PC-O24 (1.049), and ER-C5 (1.049) also showed relatively high EI
 417 values. PC-H25 had the lowest EI (-0.601), followed by PC-R10 (0.417), PC-R14
 418 (0.601), PC-R12 (0.603), and PC-R8 (0.637).

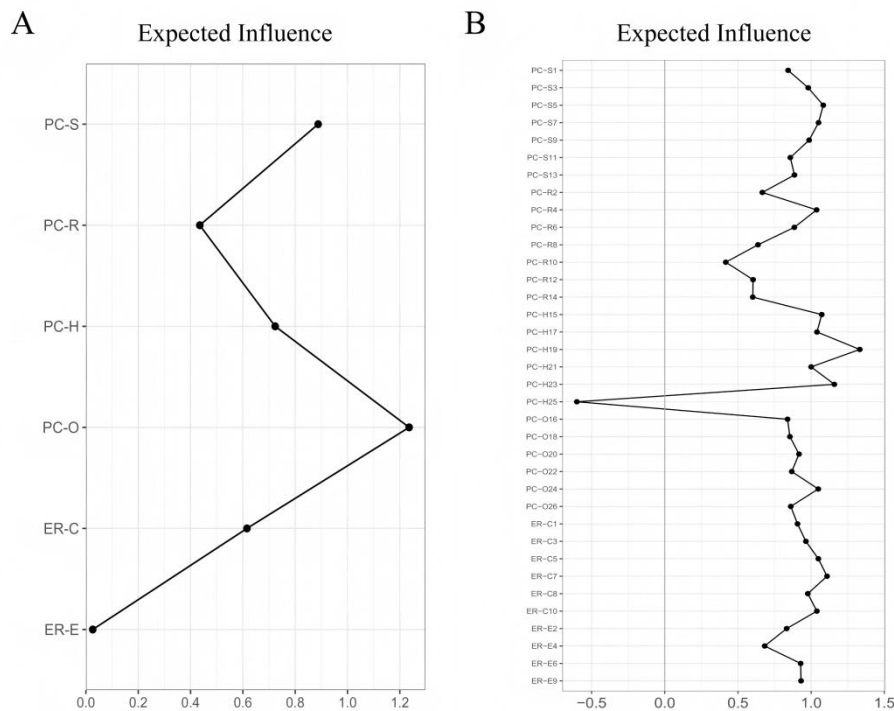


Fig 2. Expected influence of dimension level and item level networks

Betweenness

422 The betweenness centrality indices of the dimension-level and item-level
 423 networks are presented in Fig 3. At the dimension level, PC-R and PC-O showed the
 424 highest betweenness values (3 each), followed by PC-H (1), whereas PC-S, ER-C, and
 425 ER-E all had values of 0. At the item level, PC-O24 had the highest betweenness
 426 (133), followed by PC-R10 (121), PC-H25 (63), PC-R6 (59), and PC-O18 (50).
 427 Relatively high values were also observed for PC-R4 (48), PC-S13 (47), ER-C3 (47),
 428 and ER-E6 (46). In contrast, PC-R14, PC-O22, and ER-C8 had betweenness values of
 429 0, followed by PC-S1 (1) and PC-O16 and ER-E4 (4 each).

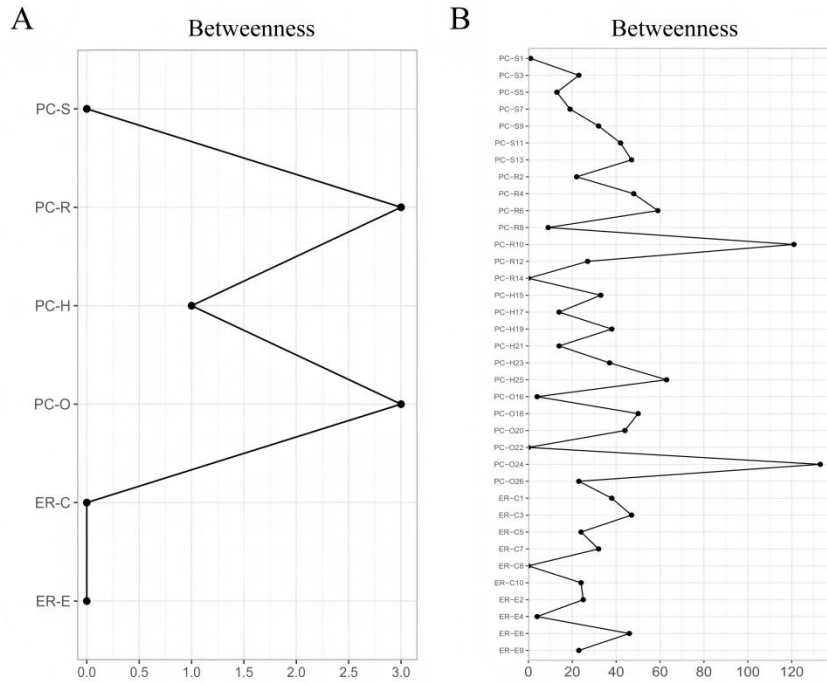


Fig 3. Betweenness centrality of dimension level and item level networks

Closeness

The closeness centrality indices of the dimension-level and item-level networks are presented in Figure 4. At the dimension level, PC-H showed the highest closeness (0.047), followed by PC-S (0.043), PC-R (0.042), and PC-O (0.040). ER-C (0.027) and ER-E (0.023) exhibited considerably lower closeness values. At the item level, PC-O24 showed the highest closeness, followed by PC-R10, PC-O20, PC-S13, and PC-S11. The lowest closeness values were observed for ER-C8, PC-S1, ER-C10, ER-E2, and ER-C7.

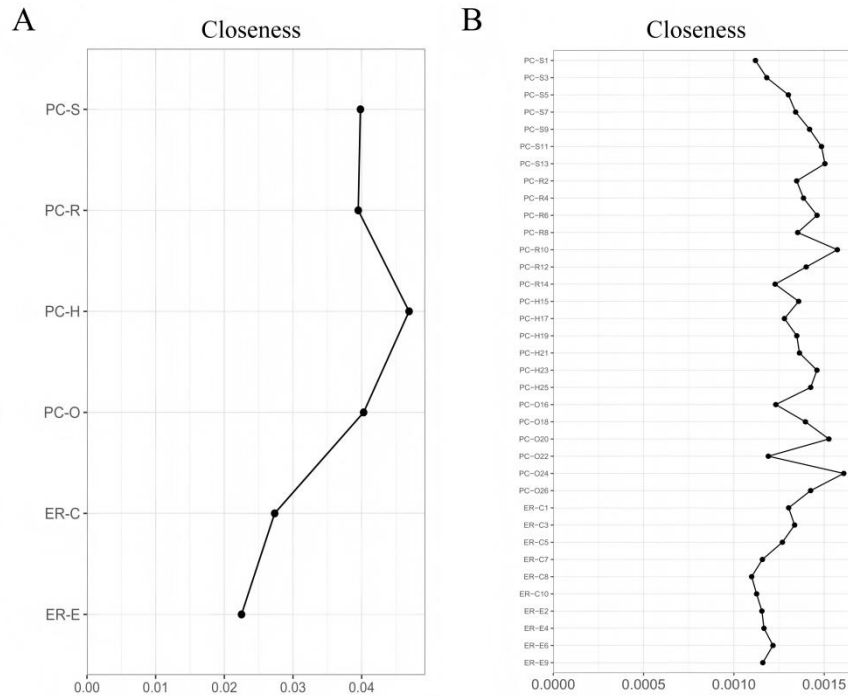


Fig 4. Closeness centrality of dimension level and item level networks

Strength

The strength centrality indices of the dimension-level and item-level networks are presented in Fig 5. At the dimension level, PC-H had the highest strength (1.372), followed by PC-O (1.270), PC-S (1.141), and PC-R (1.013). ER-C (0.616) and ER-E (0.385) showed lower strength values. At the item level, PC-O24 had the highest strength (1.414), followed by PC-R10 (1.366), PC-H19 (1.332), PC-S3 (1.271), and PC-R12 (1.249). Relatively high strength values were also observed for PC-H23 (1.158), ER-E6 (1.144), PC-S5 (1.137), ER-C7 (1.137), and PC-R4 (1.132). The lowest values were observed for PC-R2 (0.804), PC-O16 (0.851), PC-S1 (0.858), PC-O18 (0.871), and PC-O22 (0.884).

Collectively, these centrality results indicate that at the dimension level, optimism and hope consistently occupied the most central positions across EI,

454 betweenness, closeness, and strength centrality, whereas expressive suppression
 455 remained peripheral across all indices. At the item level, PC-H19, PC-O24, and
 456 PC-R10 emerged as the most influential nodes, while PC-H25 showed the lowest
 457 expected influence, suggesting its relative isolation within the network.

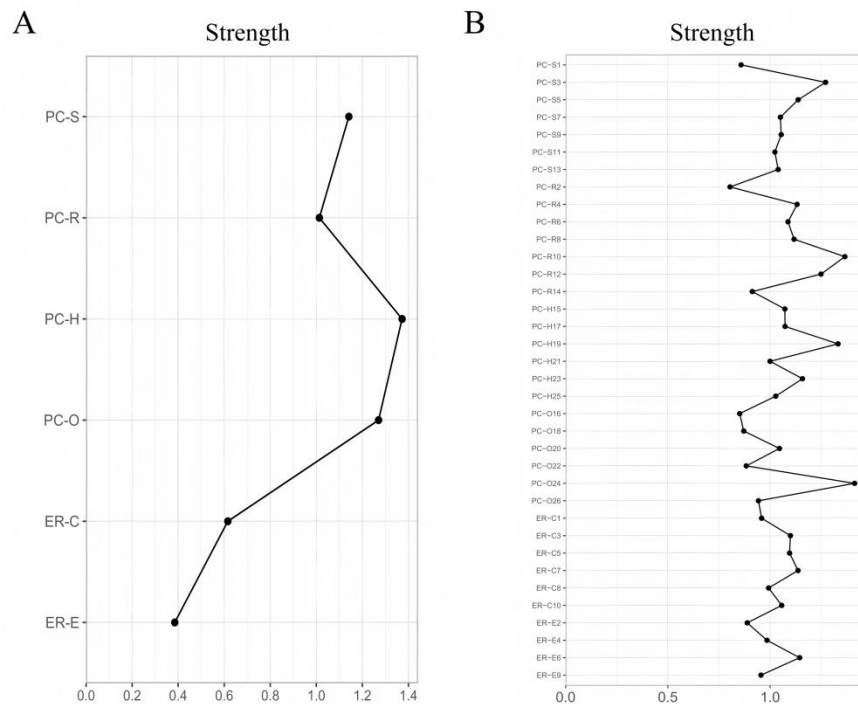
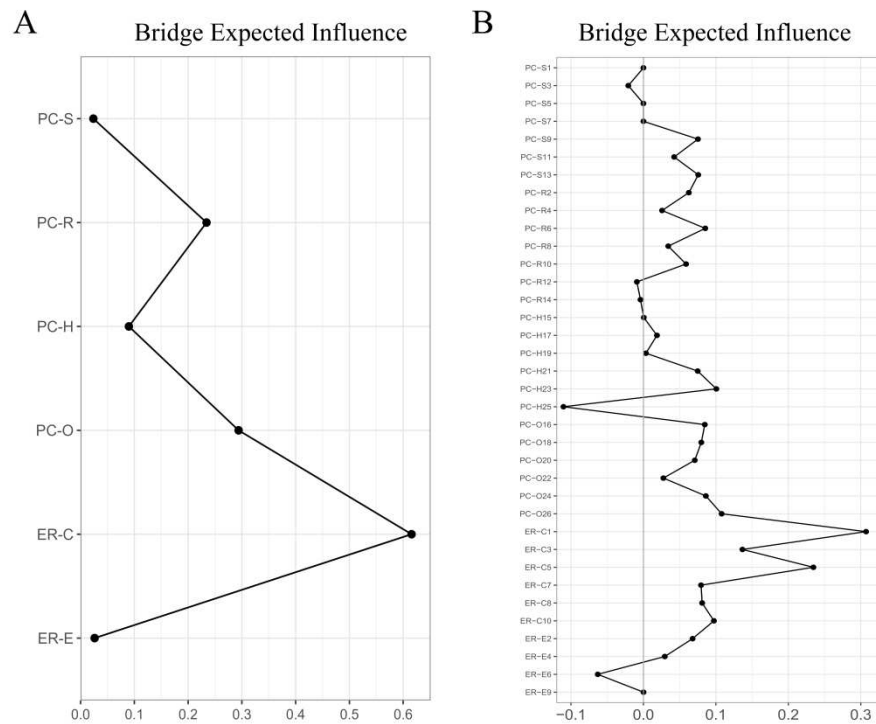


Fig 5. Strength centrality of dimension level and item level networks

Bridge Expected Influence

461 The bridge expected influence (BEI) was calculated to identify nodes with
 462 stronger connections between the PsyCap and ER clusters (Fig 6). At the dimension
 463 level, ER-C showed the highest BEI (0.616). Among the PsyCap dimensions, PC-O
 464 had the highest BEI (0.294), followed by PC-R (0.234), PC-H (0.090), and PC-S
 465 (0.024). ER-E showed a comparatively low BEI (0.026). At the item level, ER-C1
 466 showed the highest BEI (0.307), followed by ER-C5 (0.235) and ER-C3 (0.137).
 467 Within the PsyCap cluster, the highest positive BEI was observed for PC-O26 (0.108),

468 followed by PC-H23 (0.101), PC-O24 (0.086), PC-R6 (0.085), and PC-O16 (0.085).
 469 In contrast, PC-H25 showed the most negative BEI (-0.110), while ER-E6 also
 470 showed a negative BEI (-0.063).



472 **Fig 6.** Bridge Expected Influence of dimension level and item level networks.

473 Network Accuracy and Stability Estimation

474 The gray areas represent the 95% confidence intervals (CIs) of the edge weights
 475 obtained using the nonparametric bootstrap method (Fig. 7). In both the
 476 dimension-level and item-level networks, the bootstrap mean estimates were close to
 477 the original sample estimates, and the 95% CIs were generally narrow, indicating
 478 good accuracy of the estimated edge weights. The case-dropping bootstrap analysis
 479 (Fig. 8) revealed different stability patterns across the centrality indices. At the
 480 dimension level (Fig. 8A), the CS coefficients were 0.750 for expected influence,
 481 strength, closeness, and BEI, whereas betweenness showed poor stability (CS = 0). At

the item level (Fig. 8B), the CS coefficients were 0.750 for expected influence, 0.750 for strength, 0.594 for closeness, 0.517 for betweenness, and 0.750 for BEI. Thus, expected influence, strength, closeness, and BEI showed acceptable to high stability across both networks, whereas betweenness was stable only at the item level and should be interpreted cautiously at the dimension level.

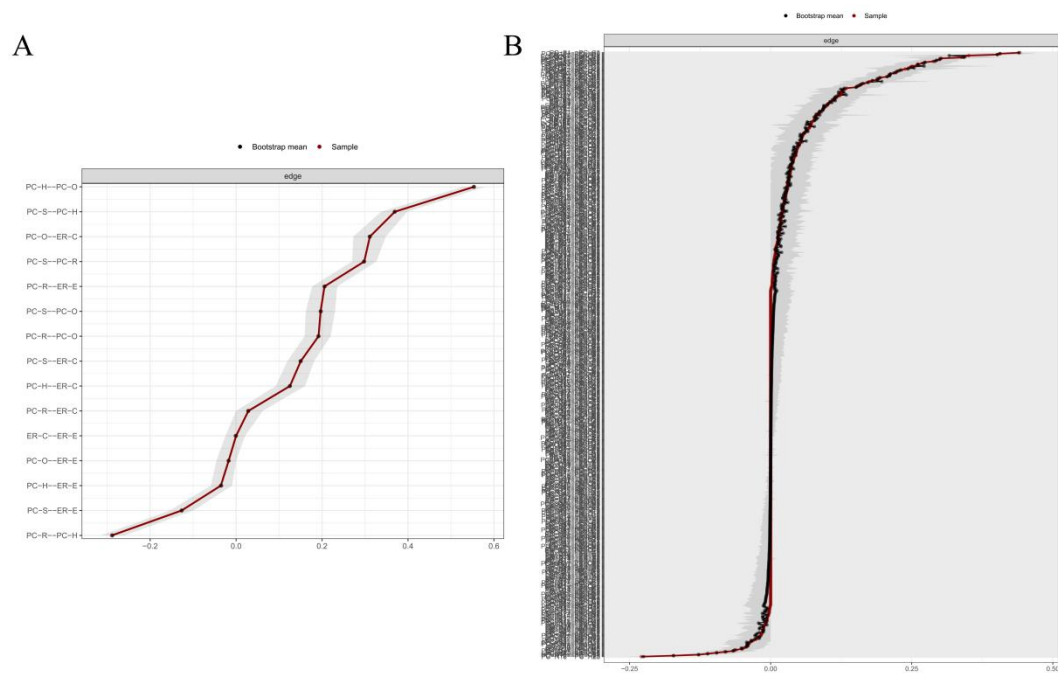


Fig 7. Nonparametric bootstrap confidence intervals for edge weights

Notes: Panel A shows the dimension-level network, and Panel B shows the item-level network. Red points represent edge-weight estimates from the original sample, black points represent bootstrap mean estimates, and gray areas represent the 95% bootstrap confidence intervals.

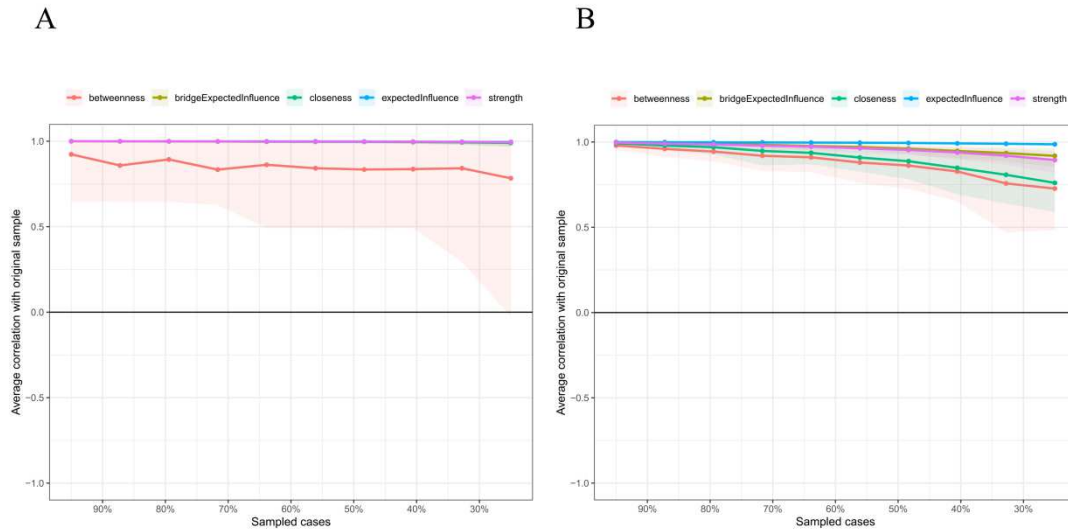


Fig. 8 Correlation stability coefficient of centrality indices

Notes: Panel A shows the dimension-level network, and Panel B shows the item-level network.

DAG networks

To examine potential directional dependencies among psychological constructs, an exploratory DAG was estimated using a bootstrap-averaged approach (Fig. 9). A total of 11 directed associations were retained in the bootstrap averaged DAG. The highest directional support was observed for the association from PC-O to ER-C, with directional support of 0.852. This was followed by the association from PC-S to ER-C (0.776) and from PC-R to PC-S (0.702). Relatively high directional support was also observed from PC-H to PC-S (0.689), PC-O to PC-S (0.685), and PC-H to ER-C (0.673).

Regarding the overall structure, PC-R occupied a relatively upstream position, with four outgoing connections and no incoming connections. ER-C and ER-E were positioned relatively downstream, with no outgoing connections. ER-C received directed connections from PC-O, PC-S, and PC-H, whereas ER-E received directed

connections from PC-R and PC-S. The remaining retained associations showed comparatively lower directional support, indicating greater uncertainty in their orientations. These directional patterns suggest a hierarchical cascade in which resilience functions as a foundational upstream resource, whereas cognitive reappraisal and expressive suppression are positioned downstream as regulatory outcomes rather than drivers of PsyCap.

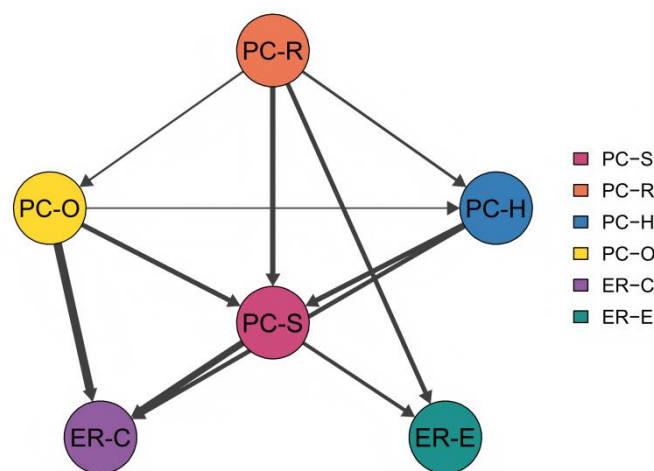


Fig 9. Exploratory DAG of PsyCap and emotion regulation.

Notes: Arrowheads indicate the orientations retained in the bootstrap averaged DAG. Line thickness is proportional to bootstrap directional support, with thicker lines indicating greater support for the displayed orientation.

Discussion

To the best of our knowledge, the present study is the first to utilize a large-sample, network-analytical approach to systematically map the structural interrelationships, bridge pathways, and directional mechanisms between PsyCap and emotion regulation among middle aged and older adults in sports club. Grounded in COR theory, our approach integrated dimension- and item-level networks, bridge

expected influence analysis, and exploratory DAG modeling, producing five interconnected insights into the organization of psychological resources among sports-active older adults. First, PsyCap and emotion regulation form a densely interconnected network characterized by a predominance of positive edges and robust cross-level structural consistency between dimensions and items. Second, within this network architecture, optimism and hope emerge as the primary core hubs, holding the highest expected influence and network strength. Third, cognitive reappraisal and optimism function as the principal bridge nodes, forming vital structural channels that link PsyCap to emotion regulation. Fourth, the network reveals marked functional heterogeneity between emotion regulation strategies: cognitive reappraisal displays consistent positive couplings across all PsyCap dimensions, whereas expressive suppression is weakly connected and displays heterogeneous, predominantly negative associations with core psychological resources. Finally, the exploratory DAG analysis demonstrates a clear hierarchical cascade, positioning resilience as a pure upstream driver that feeds into midstream PsyCap components and ultimately powers downstream emotion regulation strategies. From a COR perspective, these findings demonstrate that psychological resources and emotion regulation strategies operate as an integrated, hierarchical resource system rather than isolated constructs, providing a novel framework for psychological interventions among sports-active older adults.

Overall network architecture

The overall network architecture demonstrated that connections between PsyCap and emotion regulation are neither random nor uniform. Stronger connections were

heavily concentrated within the PsyCap domain, while cross-domain connections between PsyCap and emotion regulation were more selective. This relatively strong intra-domain connectivity aligns with the conceptualization of PsyCap as a higher-order construct in which self-efficacy, hope, optimism, and resilience represent closely related yet distinct psychological resources [10]. Furthermore, the presence of specific cross-domain edges supports direct associations between emotion regulation strategies and PsyCap dimensions [34]. The robust structural consistency observed across micro-level items and macro-level dimensions confirms that individual behavioral manifestations directly mirror higher-order resource dynamics in older adults.

From the perspective of COR theory, this dense intra-domain coupling illustrates the operation of a Resource Caravan [25]. COR theory posits that psychological resources do not exist in isolation; instead, they aggregate and co-occur because environmental conditions that foster one resource typically nourish others. In the context of older adults active in sports clubs, regular engagement in physical activity provides a unique environmental "resource passageway." Sports clubs combine physical exertion, goal-oriented skill acquisition, and structured social interaction [51]. This environment simultaneously reinforces confidence, optimism, hope, and resilience, creating a cohesive internal resource reservoir. The presence of direct, positive connections between PsyCap and cognitive reappraisal, alongside the absence of a direct edge between cognitive reappraisal and expressive suppression, further illuminates why these systems co-occur. Rather than operating as competing

processes, PsyCap resources and cognitive reappraisal form a mutually reinforcing resource cluster that supports continued engagement in sport clubs.

Network roles of PsyCap and emotion regulation

The Central influence of optimism and hope

Optimism and Hope emerged as the most prominent PsyCap dimensions, though their centrality was reflected in different indices. Optimism showed the highest expected influence, while Hope had the highest strength. This distinction is meaningful: strength reflects the overall magnitude of a node's connections, whereas expected influence also accounts for their direction. Hope was strongly connected with several dimensions, but its negative tie with Resilience reduced its net influence; Optimism, in contrast, was linked mainly through positive edges. At the item level, PC-H19 ("I pursue my goals actively") had the highest expected influence and was closely associated with PC-H17 ("I am working hard to meet my goals"), highlighting Hope's role in sustained goal pursuit. PC-O24 ("I think life is wonderful") showed the highest strength and was strongly connected with PC-O20 ("I think good people are still the majority in society"), reflecting Optimism's broader positive outlook.

The prominence of Hope and Optimism is particularly relevant for older adults engaged in organized sport. Sustained participation requires adapting to changing physical capacities while maintaining motivation, goal commitment, and positive expectations. Hope supports this process by enabling individuals to set, revise, and pursue meaningful goals despite shifting circumstances, consistent with evidence on goal adjustment and perceived progress in later life [52,53]. Optimism complements

this function by fostering a generalized positive orientation toward life and future possibilities. This is especially important in sports-club contexts, where participants repeatedly encounter performance feedback, physical challenges, and social interaction [54,55]. Together, Hope and Optimism occupy central positions because they meet two complementary demands of later-life sport participation: continuing to pursue meaningful goals while sustaining a positive outlook toward ongoing engagement.

Bridge pathways connecting PsyCap and emotion regulation

Cognitive reappraisal emerged as the principal interface between PsyCap and emotion regulation. On the ER side, ER-C1 (“When I want to feel more positive emotion, I change what I’m thinking about”), ER-C5 (“When I’m faced with a stressful situation, I make myself think about it in a way that helps me stay calm”), and ER-C3 (“When I want to feel less negative emotion, I change what I’m thinking about”) showed the strongest positive bridge roles. These nodes concentrated several of the most robust PsyCap–ER connections, indicating that psychological resources link to regulation primarily through the reinterpretation of stressful experiences. On the PsyCap side, PC-O26 (“I think the future is full of hope”), PC-H23 (“I know exactly what kind of life I want”), and PC-O24 (“I think life is wonderful”) displayed relatively high bridge influence. Notably, PC-O24 also had the highest strength and betweenness, while ER-C3 combined bridge influence with high betweenness and a direct tie to resilience, suggesting that these nodes form key pathways between the two systems. In contrast, ER-E6 (“I control my emotions by not expressing them”)

showed negative bridge influence and was involved in one of the strongest negative PsyCap–ER connections, underscoring that expressive suppression is peripheral and may even hinder positive resource–regulation linkages.

From a COR perspective, this bridge pattern illustrates how broad psychological resources are mobilized to meet immediate emotional demands. Hope, optimism, resilience, and confidence may constitute a wider reserve, while cognitive reappraisal functions as a proximal mechanism that deploys these reserves to maintain emotional stability and goal pursuit [25]. This mechanism is particularly salient in organized sport among older adults, where participation involves health, social interaction, challenge, and achievement [55]. Under such conditions, positive expectations and clear goal direction provide resources that can be activated through cognitive reappraisal when setbacks occur, enabling older adults to regulate emotions without disengaging from valued participation.

Differential network roles of cognitive reappraisal and expressive suppression

A clear divergence emerged between the two emotion regulation strategies. Cognitive reappraisal showed consistently positive links across all PsyCap dimensions, while expressive suppression was weakly connected and often negatively associated with core psychological resources. Under COR theory, this contrast reflects their different cognitive demands and social consequences within resource gain versus loss spirals. As an antecedent-focused strategy, reappraisal alters the evaluation of events before emotions fully develop [17]. By reframing unfavorable athletic or physical experiences, older adults can prevent stressors from draining psychological

reserves, thereby sustaining optimism, self-efficacy, and recovery capacity [56,57].

Although reappraisal requires executive control resources in later life [58], its integration throughout the network highlights its role in initiating and sustaining resource gain spirals.

In contrast, suppression operates as a response-focused strategy, requiring continuous effort to inhibit emotional expression after emotions have already been triggered [17]. This ongoing self-monitoring consumes cognitive resources without replenishing psychological assets [19]. Moreover, sports clubs thrive on shared emotional expression and team communication; habitual suppression can create interpersonal friction and limit social support, explaining its negative ties with self-efficacy, hope, and optimism. Interestingly, suppression did show a positive link with resilience. In group sport contexts, temporarily withholding negative outbursts may help maintain harmony and protect relationships that support continued participation [59,60]. Thus, suppression should not be viewed as uniformly maladaptive; rather, it may serve as a situational strategy for preserving social resources, even if its broader network role remains peripheral.

Causal discovery and hierarchical directional pathways in the DAG analysis

The exploratory DAG revealed a structured, directional resource hierarchy. Resilience (PC-R) occupied a purely upstream position, featuring four outgoing connections and no incoming edges. Midstream PsyCap components (optimism, hope, and self-efficacy) received directional inputs from resilience and transmitted pathways

downstream, whereas emotion regulation strategies (cognitive reappraisal and expressive suppression) were positioned at the downstream terminal end, functioning as sink nodes that receive but do not transmit directional influence. This directional cascade reflects the functional organization of psychological resources in sports-active older adults under COR theory, in which resilience serves as the foundational resource that supports positive future expectations and reinforces agency in overcoming challenges. As an upstream source, resilience provides the essential psychological baseline for older adults to recover from physical strain, fatigue, and health setbacks inherent in later-life exercise, a particularly relevant capacity given that COR theory proposes that resource-rich individuals are more capable of investing existing reserves in further adaptation [25]. Optimism, hope, and self-efficacy function as midstream mediators that process the foundational security provided by resilience, translating it into active goal pursuit and situational confidence [52]. Emotion regulation strategies sit at the terminal end of this cascade because strategy deployment requires upstream energy reserves: older adults do not readily employ cognitive reappraisal; rather, they reframe stressful sports situations when supported by the upstream confidence and optimism generated by their resilience foundation [55]. Expressive suppression occupies a more constrained downstream position, serving as a situational response when immediate emotional expression must be controlled, consistent with its comparatively weak and heterogeneous connections observed in the undirected network.

Implications

Theoretical Implications

The findings of this study extend COR theory by applying a network psychometrics framework to reveal the micro-level organization of psychological resources. Rather than assuming uniform aggregation through composite scores or latent models, the results show that resources form a highly interconnected network with identifiable bridge nodes and directional flows. This perspective provides a more detailed picture of how resource caravans co-occur and reinforce one another in everyday contexts. A further implication lies in clarifying the resource and strategy nexus in aging populations. The observed directional cascade, from resilience at the upstream level through optimism and self-efficacy to cognitive reappraisal downstream, illustrates how dispositional resources may support situational coping in sports-active older adults.

Practical Implications

From a practical standpoint, the network architecture offers guidance for designing interventions and community sport programs. The centrality results suggest that focusing on key nodes such as optimism and cognitive reappraisal may yield broader systemic benefits. For example, rather than offering general emotion regulation training, programs could emphasize mindfulness or CBT-based workshops, and structured group exercise such as yoga or dance, which are more likely to generate positive spillovers across the network. In addition, sports clubs can be organized to foster resilience through progressive physical challenges, while also supporting participants in reframing fatigue or performance setbacks constructively.

Such approaches may help older adults sustain their psychological resources and remain engaged in organized sport.

Limitations and Future Directions

Despite its contributions, several methodological limitations should be acknowledged. First, the cross-sectional design prevents causal inference regarding the DAG pathways. Future research should adopt longitudinal panel designs, temporal network models, or Ecological Momentary Assessment (EMA) to test whether upstream PsyCap changes dynamically precede downstream regulation. Second, reliance on self-report questionnaires introduces risks of shared method variance, social desirability, and retrospective bias. Combining real-time experience sampling with objective physiological markers (e.g., heart rate variability) and behavioral tracking during athletic events would enhance measurement precision and ecological validity. Third, the exclusive recruitment of healthy, active sports club members limits generalizability. Future studies should examine more heterogeneous cohorts—including sedentary, frail, or clinical populations—and apply Network Comparison Tests (NCT) to evaluate structural invariance across diverse groups.

Conclusion

This study systematically mapped the interconnections between PsyCap and emotion regulation among middle aged and older adults in sports clubs, using a network psychometrics framework grounded in COR theory. The results highlighted optimism and hope as central PsyCap dimensions, reflecting their dual roles in

sustaining goal pursuit and maintaining a positive outlook on life. Cognitive reappraisal emerged as the principal bridge strategy linking PsyCap to emotion regulation, underscoring its role as a proximal mechanism through which broader psychological resources are mobilized to regulate emotional demands. The exploratory DAG further revealed a hierarchical cascade, with resilience functioning as an upstream source that channels into optimism, hope, and self-efficacy, which in turn support downstream regulatory strategies.

Together, these findings advance theoretical understanding by clarifying the structural pathways through which dispositional resources empower situational coping in later life. Practically, they suggest that interventions targeting optimism and cognitive reappraisal may yield systemic benefits, while sports clubs can be designed to foster resilience through progressive challenges and supportive environments. By integrating PsyCap and emotion regulation within a network framework, this study contributes to the healthy-ageing agenda by demonstrating how psychological resources and regulatory strategies dynamically interact to sustain engagement, adaptation, and psychosocial well-being in older adulthood.

Abbreviations

PsyCap: Psychological capital; ER: Emotion regulation; PPQ: Positive Psychological Capital Questionnaire; ERQ: Emotion Regulation Questionnaire; PA: Physical activity; PARS-3: Physical Activity Rating Scale-3; COR: Conservation of Resources theory; DAG: Directed acyclic graph

Declarations

Ethics approval and consent to participate

This study was performed in accordance with the principles of the Declaration of Helsinki. The study protocol was approved by the Sports Science Experiment Ethics Committee of Beijing Sport University (protocol code 202305H). Clinical trial number: not applicable. All ethical standards were followed in all aspects of the work reported in this manuscript. All participants participated voluntarily and provided written informed consent prior to enrollment.

Consent for publication

Not applicable.

Availability of data and materials

The authors declare that all data generated or analyzed during this study are included in this published article and its supplementary information files. Deidentified data are available for academic research upon reasonable request from the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

LJY conceptualized and designed the study, conducted data analysis and interpretation, and was responsible for manuscript drafting, review, and editing. CJY participated in data collection, data curation, and contributed to manuscript revision. QYJ supervised the project, participated in the conceptualization and design of the study, provided critical guidance throughout the research process, and contributed to manuscript review and editing. All authors have read and agreed to the published version of the manuscript.

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Table 1. Basic characteristics of the nodes in the item network

Nodes	Abbreviation	M	SD
Psychological capital (PC)			
Self-efficacy (S)			
PC-S1: Some people around me appreciate my talent and capability.	PC-S1	5.08	1.579
PC-S3: I have more opinions and abilities than ordinary people.	PC-S3	5.00	1.435
PC-S5: I am confident in my abilities.	PC-S5	5.71	1.231
PC-S7: I can always do a good job.	PC-S7	5.73	1.233
PC-S9: In the face of difficulties, I will stay calm and seek solutions.	PC-S9	5.66	1.181
PC-S11: I would like to take on difficult and challenging work.	PC-S11	5.22	1.384
PC-S13: In adversity, I will actively try different coping methods.	PC-S13	5.36	1.269
Resilience (R)			
PC-R2: I am not a testy person.	PC-R2	5.67	1.403
PC-R4: I quickly get over and recover from setbacks.	PC-R4	5.69	1.252
PC-R6: I don't care much about the unhappiness in life.	PC-R6	5.61	1.289
PC-R8: A bad experience will make me feel depressed for a long while. (*)	PC-R8	3.45	1.807
PC-R10: I feel tired and overburdened. (*)	PC-R10	2.85	1.752
PC-R12: I tend to get frustrated when things are not going well. (*)	PC-R12	3.11	1.704
PC-R14: When I am under a lot of pressure, I have difficulty eating or sleeping well. (*)	PC-R14	3.97	1.849
Hope (H)			
PC-H15: I work hard to accomplish my goals.	PC-H15	5.63	1.205
PC-H17: I am working hard to meet my goals.	PC-H17	5.63	1.208
PC-H19: I pursue my goals actively.	PC-H19	5.78	1.151

Nodes	Abbreviation	M	SD
PC-H21: I have certain plans for my future.	PC-H21	5.69	1.143
PC-H23: I know exactly what kind of life I want.	PC-H23	5.90	1.078
PC-H25: I don't know what my life aim is. (*)	PC-H25	4.84	1.847
Optimism (O)			
PC-O16: In uncertain situations, I always expect good results.	PC-O16	5.34	1.271
PC-O18: I usually look on the bright side of things.	PC-O18	5.68	1.236
PC-O20: I think good people are still the majority in society.	PC-O20	6.11	1.046
PC-O22: Most of the time, I am in high and vigorous spirits.	PC-O22	5.69	1.2
PC-O24: I think life is wonderful.	PC-O24	6.18	1.027
PC-O26: I think the future is full of hope.	PC-O26	5.90	1.149
Emotion regulation (ER)			
Cognitive reappraisal (C)			
ER-C1: When I want to feel more positive emotion (such as joy or amusement), I change what I'm thinking about.	ER-C1	5.87	1.119
ER-C3: When I want to feel less negative emotion (such as sadness or anger), I change what I'm thinking about.	ER-C3	5.71	1.125
ER-C5: When I'm faced with a stressful situation, I make myself think about it in a way that helps me stay calm.	ER-C5	5.63	1.105
ER-C7: When I want to feel more positive emotion, I change the way I'm thinking about the situation.	ER-C7	5.61	1.112
ER-C8: I control my emotions by changing the way I think about the situation I'm in.	ER-C8	5.41	1.17
ER-C10: When I want to feel less negative emotion, I change the way I'm thinking about the situation.	ER-C10	5.50	1.113
Expressive suppression (E)			
ER-E2: I keep my emotions to myself.	ER-E2	5.12	1.481
ER-E4: When I am feeling positive emotions, I am careful not to express them.	ER-E4	4.73	1.693
ER-E6: I control my emotions by not expressing them.	ER-E6	4.86	1.576

Nodes	Abbreviation	M	SD
ER-E9: When I am feeling negative emotions, I make sure not to express them.	ER-E9	5.02	1.499

935 *Notes:* *M* = mean; *D* = standard deviation; (*) = reverse-scored item.