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Cultivation and Differential Development of Mental Health and Subjective Happiness of Seniors Based on Sports Dance

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Abstract
Age-friendly sports can effectively alleviate the pressure of population aging on economy and society. Many studies have discussed the motives, current states, and favorite sports of seniors participating in physical exercise. However, there is little report on the evaluation of the health of seniors in sports dance, or the gradual cultivation of mental health and subjective happiness of seniors. Therefore, this paper explores the cultivation and differential development of mental health and subjective happiness of seniors based on sports dance. Firstly, a scientific evaluation index system (EIS) was constructed for the health of seniors in sports dance. Next, a matter-element extension model was established, and the detection methods were developed for the evaluation criteria. Finally, the flow of index weighting was explained. Through experiments, the authors analyzed the difference among seniors in mental health improvement and subjective happiness cultivation under the intervention of sports dance. The research results provide a reference for how the mental health and subjective happiness of seniors are affected by the scientific training and benign development of sports dance, as well as long-term exercise of sports dance.
Keywords: sports dance; seniors; mental health; subjective happiness

Introduction

It is estimated that, by 2025, China's population older than 60 will reach 423 million. The acceleration of population aging pushes the country gradually to the phase of old-age society (Kallen et al., 2020; Latorre et al., 2020; Schepers et al., 2020; Wei et al., 2020; Yang et al., 2019; Zhu & Zheng, 2020). Therefore, the development of age-friendly sports has attracted much attention from the Chinese leadership (Branco et al., 2019; Wu & Tien-Liu, 2020). Age-friendly sports can promote the mental and physical health of seniors, strengthen their physique, and reduce the incidence of chronic diseases, thereby alleviating the pressure of population aging on economy and society (Barkoukis et al., 2017; Beaumont et al., 2019; Haiying Wang, 2020; Lenné et al., 2012; Li, 2021; Marquardt et al., 2019; Wang et al., 2020).

Zhao (2014)surveyed the current mental needs of sports among seniors in rural settlements and identified the lack of sites and coaches as the main reasons for the low enthusiasm for physical exercise among rural seniors. Through questionnaire survey and mathematical statistics, Shin et al. (2013) studied the current physical and mental states of senior women in urban areas participating in physical exercise and summarized the following physical and mental motives for them to take physical exercise: enhance physical quality, prevent chronic diseases, maintain health, preserve self-care ability, keep social interactions, rid negative emotions, lose weight, and realize bodybuilding. Kawata et al. (2015) examined the diverse mental states of seniors in physical exercise, and recognized the main mentalities: maintain health, cure disease, and make close friends. Heazlewood et al. (2011) combed through the main types of sports needs among seniors (e.g., physical health, entertainment, social interaction, spiritual and cultural life, and disease prevention and treatment), and investigated the disparity in sports needs among seniors of different ages, education backgrounds, and occupations. (Roja et al., 2018) measured the differences among senior sports behaviors with exercise frequency, duration per exercise, and exercise intensity. (Rodrigues & do Amaral, 2015) put forward suggestions on enhancing the physical exercise awareness and participation of seniors with a poor mental health: teach more knowledge and methods of physical exercise; diversify the means and forms of physical exercise; provide consultation and counseling of mental health; improve the utilization rate of public sports sites and equipment.

Many scholars at home and abroad have investigated the relationship between mental health and physical exercise intervention of seniors. Most of them focus on the motives, current states, and favorite sports of seniors participating in physical exercise (Haslam et al., 2019; Kirk et al., 2013; Perroni et al., 2009; Van Holle et al., 2014). There is little report that evaluates the health of sports dance among seniors (Andrews et al., 2017; Chekroud et al., 2018). As for the influence of sports dance on the mental health of seniors, very few researchers explicitly pointed out that the mental health and subjective happiness of seniors should be cultivated gradually.

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Therefore, this paper explores the cultivation and differential development of mental health and subjective happiness of seniors based on sports dance. Section 2 sets up a scientific evaluation index system (EIS) (Ou & Chen, 2020; Quan Zhang, 2020; Zhe Xu, 2020) for the health of seniors in sports dance. Section 3 establishes a matter-element extension model, and explains the detection methods for the evaluation criteria. Section 4 defines the flow of index weighting. Finally, an experimental analysis was carried out to disclose the difference among seniors in mental health improvement and subjective happiness cultivation under the intervention of sports dance.

This research promotes the scientific development of sports dance among seniors, enhances the awareness of sports dance of the elderly, and benefits the mass sports campaign. In addition, the research results provides a demonstrative framework of national sports dance, and offers a practical model of regular and scientific development of sports dance in China.

EIS Construction

This paper sets up the following EIS for the health of seniors in sports dance. The modeling hypotheses are shown in Figure 1.

Layer 1 (primary index):

HB= {health of sports dance}

Layer 2 (secondary index):

HB= {HB_1, HB_2, HB_3, HB_4} = {formation of sports dance awareness, cultivation of sports dance habit, mastery of sports dance knowledge, maintenance of mental health} 。

Layer 3 (criteria):

HB_1= {HB_{11}, HB_{12}, HB_{13}, HB_{14}} = {sports dance learning ability, sports dance interest and preference, sports atmosphere of training sites, attention from family}.

HB_2= {HB_{21}, HB_{22}, HB_{23}, HB_{24}} = {physical fitness improvement, self-control ability, endurance, emotional experience}.

HB_3= {HB_{31}, HB_{32}, HB_{33}} = {reparatory sports knowledge, basic knowledge experience of sports dance, sports safety knowledge}

HB_4= {HB_{41}, HB_{42}, HB_{43}, HB_{44}} = {reasonable expression of bad emotions, keeping optimistic, stepping up psychological exchanges with peers, paying attention to healthy diet}.

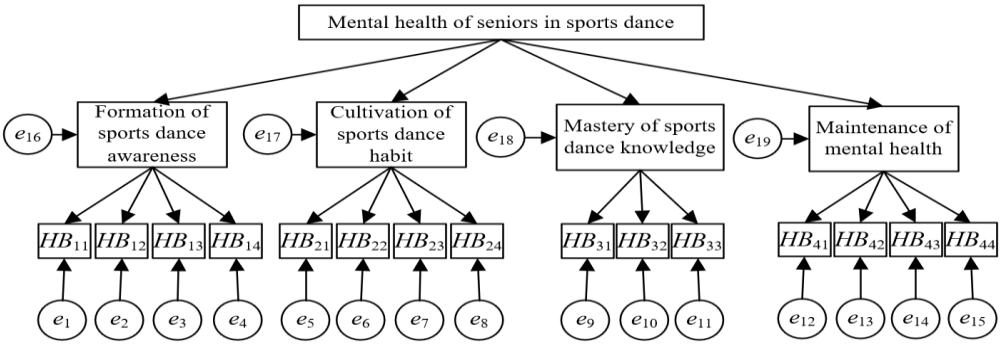

Figure 1. Modeling hypotheses

Matter-Element Extension Model and Criteria Detection

Matter-element analysis was proposed by Chinese scholar Cai Wen in the 1980s to solve contradiction problems. It is an effective way to study matter elements and their change laws and solve the incompatible problems in the real world. The method has been successfully applied to comprehensive evaluations of eco-environment, water carrying capacity, farmland grading, and land ecological level, etc. Based on the EIS for the health of seniors in sports dance, this paper applies fuzzy matter-element method to compute the efficacy index of behaviors.

Modeling

Figure 2 shows the flow of FAHP-based evaluation. The mental health of seniors in sports dance is influenced by various factors. It is a complex problem to evaluate the mental health of these seniors. Matter-element extension model can abstract the complex problem into logical cells called matter elements, which consists of the features and values of evaluation indices, making it possible to establish a multi-index evaluation model.

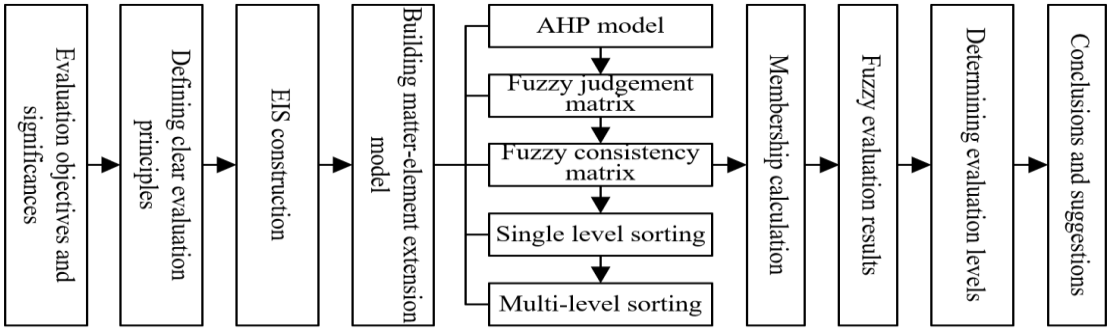

Figure 2. Fuzzy analytic hierarchy process (FAHP)-based evaluation flow

To evaluate the mental health of seniors in sports dance, each matter element can be described as an ordered triple $EL=(M, D, a)$. Suppose criterion M has n eigenvectors $\{D_1, D_2, \ldots, D_n\}$, which correspond to eigenvalues $\{a_1, a_2, \ldots, a_n\}$. Then, the ordered triple EL can be defined as an n-dimensional fuzzy matter element. If there are m criteria, an n-dimensional composite fuzzy matter element can be established:

$$EL=\begin{Bmatrix} & M_1 & M_2 & \cdots & M_m \\ D_1 & a_{11} & a_{21} & \cdots & a_{m1} \\ D_2 & a_{21} & a_{22} & \cdots & a_{m2} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ D_n & a_{1n} & a_{2n} & \cdots & a_{mn} \end{Bmatrix} \quad (1)$$

It is assumed that e profile statistics samples are collected for each criterion. Then, e n-dimensional composite fuzzy matter elements can be developed for the m criteria:

$$B_e=\{EL_1, EL_2, \ldots, EL_e\} \quad (2)$$

The classical domain for the mental health evaluation of seniors in dance sports can be described by a classical domain matter-element matrix $EL_{CD\text{-}jt}=(M_{CD\text{-}jt}, D_j, A_{CD\text{-}jt})$. Let $M_{CD\text{-}t}$ be the t-th evaluated level of the mental health of seniors in dance sports; D_j be the eigenvector; $A_{CD\text{-}jt}$ be the value range $(g_{CD\text{-}jt}, h_{CD\text{-}jt})$ of the t-th level corresponding to the j-th eigenvector. Then, a composite classical domain matter element can be constituted:

$$EL_{CD-jt}=\begin{Bmatrix} & M_{CD-1} & M_{CD-2} & \cdots & M_{CD-t} \\ D_1 & (g_{CD-11}, h_{CD-11}) & (g_{CD-21}, h_{CD-21}) & \cdots & (g_{CD-t2}, h_{CD-t2}) \\ D_2 & (g_{CD-12}, h_{CD-12}) & (g_{CD-22}, h_{CD-22}) & \cdots & (g_{CD-t2}, h_{CD-t2}) \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ D_j & (g_{CD-1j}, h_{CD-1j}) & (g_{CD-2j}, h_{CD-2j}) & \cdots & (g_{CD-tj}, h_{CD-tj}) \end{Bmatrix} \quad (3)$$

The node domain for the mental health evaluation of seniors in dance sports can be described by $EL_w=(M_w, D_j, A_{wj})$. Let A_{wi} be the value range (g_{wj}, h_{wj}) of the j-th eigenvector of node domain matter element. Then, the specific node domain matter element matrix can be expressed as:

$$EL_w=(M_w, D_j, A_{wj})=\begin{Bmatrix} & M_w \\ D_1 & (g_{w1}, h_{w1}) \\ D_2 & (g_{w2}, h_{w2}) \\ \cdots & \cdots \\ D_j & (g_{wj}, h_{wj}) \end{Bmatrix} \quad (4)$$

Let a_j be the value of a matter element for the mental health evaluation of seniors in dance sports; $A_{CD\text{-}jt}$ be the corresponding value range in the classical domain; A_{wj} be the value range in the node domain; $l\,(d_j)_t$ be the correlation of the j-th criterion with the t-th level; $\sigma\,(a_j, A_{CD\text{-}jt})$ and $\sigma_{wj}\,(a_j, A_{wj})$ be the distance from a_j to $A_{CD\text{-}jt}$ and A_{wj}, respectively. Then, the correlation can be determined by:

$$l_{(D_i)}=\begin{cases} \frac{-\sigma(a_j, A_{CD-jt})}{|A_{CD-jt}|} & a_j \in A_{CD} \\ \frac{\sigma(a_j, A_{CD-jt})}{\sigma_{wj}(a_j, A_{wj})-\sigma(a_j, A_{CD-jt})} & a_j \notin A_{CD} \end{cases} \quad (5)$$

where,

$$\begin{cases} \sigma(a_j, A_{CD-jt})=\left|a_j-\frac{1}{2}(g_{CD-jt}, h_{CD-jt})\right|-\frac{1}{2}(h_{CD-jt}-g_{CD-jt}) \\ \sigma_{wj}(a_j, A_{wj})=\left|a_j-\frac{1}{2}(g_{wj}, h_{wj})\right|-\frac{1}{2}(h_{wj}-g_{wj}) \\ A_{CD-jt}=|h_{CD-jt}-g_{CD-jt}|, A_{wj}=[g_{wj}, h_{wj}] \end{cases} \quad (6)$$

Let θ_j be the weight of the j-th criterion. Then, the composite correlation $L_{T,\,M}$ of criterion M with each level can be calculated by:

$$L_{T,M}=\sum_{j=1}^{n}\theta_j l_{(D_j)t} \quad (7)$$

Let $L_{t,\,M}$ be the composite correlation of criterion M with the t-th level, i.e., the membership of the criterion to the level. Then, the composite correlation of the object can be quantified as:

$$L_{t,M}^{*}=\frac{L_{t,M}-min(L_{t,M})}{max(L_{t,M})-min(L_{t,M})} \quad (8)$$

Then, the evaluation index W of the object can be calculated by:

$$W=\frac{\sum_{t=1}^{5} tL_{t,M}^{*}}{\sum_{t=1}^{5} L_{t,M}^{*}} \quad (9)$$

Index detection

Let $a_{0\text{-}j}$ be the original data of the j-th criterion; $g_{0\text{-}j}$ and $h_{0\text{-}j}$ be the lower and upper bounds under the j-th criterion, respectively. Then, the dimensionless result e_{jt} of the j-th criterion relative to the t-th level can be calculated by:

$$e_{jt}=\frac{a_{0\text{-}j}-g_{0\text{-}j}}{h_{0\text{-}j}-a_{0\text{-}j}} \quad (10)$$

The obstacle distance of a criterion is equivalent to the distance r_{it} from the j-th index to the training objective of subjective happiness of seniors:

$$r_{jt}=1-e_{jt} \quad (11)$$

Let γ be the level of a criterion; N_{IB} be the total number of levels for index obstacle. Then, the obstacle level γ_{jt} of an index can be determined by:

$$\gamma_{jt}=N_{IB}-\gamma \quad (12)$$

The obstacle degree ψ_{jt} of the j-th criterion can be calculated by:

$$\psi_{jt}=\frac{r_{jt}\cdot\theta_j\cdot\gamma_{jt}}{\sum_{j=1}^{m}(r_{jt}\cdot\theta_j\cdot\gamma_{jt})} \quad (13)$$

The mean obstacle degree $T_j\psi_j$ of the j-th criterion can be calculated by:

$$\psi_j=\frac{\sum_{\omega=1}^{e}\psi_{jt}}{\sum_{\omega=1}^{e}\sum_{j=1}^{n}\psi_{jt}} \quad (14)$$

Index Weighting

Under the intervention of sports dance, the mental health and subjective happiness of seniors need to be improved gradually. The entropy method mentioned above mainly applies to the statistical samples from independent profiles. However, this paper needs to process the long-term sequential panel data about the training of mental health and subjective happiness of seniors under the intervention of sports dance. If the entropy weight is solved for each statistical sample from independent profiles, the evaluated levels will not be so accurate. To solve the problem, the time variable was introduced to the entropy method. Let $a_{\omega ij}$ be the original value of the j-th criterion in the i-th phase in year ω; $max\,(a_{\omega 1j}, a_{\omega 2j}, \ldots, a_{\omega ij})$ and $min\,(a_{\omega 1j}, a_{\omega 2j}, \ldots, a_{\omega ij})$ be the corresponding maximum and minimum, respectively. Then, $a_{\omega ij}$ can be normalized into $a_{\omega ij}^{*}$ by:

$$a^*_{\omega ij}=\begin{cases}\frac{a_{\omega ij}-min(a_{\omega 1j},a_{\omega 2j}\cdots a_{\omega ij})}{max(a_{\omega 1j},a_{\omega 2j}\cdots a_{\omega ij})-min(a_{\omega 1j},a_{\omega 2j}\cdots a_{\omega ij})}\\ \frac{max(a_{\omega 1j},a_{\omega 2j}\cdots a_{\omega ij})-a_{\omega ij}}{max(a_{\omega 1j},a_{\omega 2j}\cdots a_{\omega ij})-min(a_{\omega 1j},a_{\omega 2j}\cdots a_{\omega ij})}\end{cases} \quad (15)$$

Suppose

$$b_{ij}=a^*_{ij}/\sum_i a^*_{ij} \quad (16)$$

The traditional entropy method ignores the special case that lnb_{ij} is meaningless at A_{ij}^*=0. Considering this special case, formula 16 can be adjusted into:

$$b_{\omega ij}=\frac{a^*_{\omega ij}+1}{\sum_\omega\sum_i\left(a^*_{\omega ij}+1\right)} \quad (17)$$

Let EO be the number of evaluation time series; ES be the number of phases in each time series. Then, the entropy DV_j of the j-th criterion after the addition of time variable can be calculated by:

$$DV_j=-\upsilon\sum_\omega\sum_i b_{ij}ln\left(b_{\omega ij}\right) \quad (18)$$

where, υ can be calculated by:

$$\upsilon=ln(EO\cdot ES) \quad (19)$$

The difference coefficient, i.e., the utility UV_j of the j-th criterion, can be calculated by:

$$UV_j=1-DV_j \quad (20)$$

The weight θ_j of the j-th criterion can be determined by:

$$\theta_j=\frac{UV_j}{\sum_j UV_j} \quad (21)$$

Let ε be the number of primary indices; θ_j be the weight of the j-th primary index. Then, the weight β_ε of the ε-th primary index can be determined by:

$$\beta_\varepsilon=\sum_j\theta_j \quad (22)$$

Ten psychological experts were invited to rate the importance of each index for seniors' mental health in sports dance, and their ratings were compared in detail. The ten experts shared their views on the panel data samples from ten continuous evaluation phases, forming 10 evaluation results. Based on these results, the training effect of seniors' mental health and subjective happiness was quantified and analyzed under the intervention of sports dance. The quantification refers to the 9-point scale in FAHP. The expert ratings are listed in Table 1.

Table 1

Importance scores of primary indices

Index	HB_1	HB_2	HB_3	HB_4
HB_1	0.5	0.49	0.66	0.54
HB_2	0.51	0.5	0.51	0.58
HB_3	0.34	0.49	0.5	0.32
HB_4	0.46	0.42	0.68	0.5

Based on the data in Table 1, the fuzzy judgement matrix for mental health evaluation of seniors in sports dance can be constructed as:

$$G=\begin{bmatrix}0.5 & 0.49 & 0.66 & 0.54\\ 0.51 & 0.5 & 0.51 & 0.58\\ 0.34 & 0.49 & 0.5 & 0.32\\ 0.46 & 0.42 & 0.68 & 0.5\end{bmatrix} \quad (23)$$

By FAHP, matrix G was subject to consistency adjustment. The resulting fuzzy consistency matrix P can be expressed as:

$$P=\begin{bmatrix}0.5 & 0.51 & 0.54 & 0.59\\ 0.49 & 0.50 & 0.56 & 0.51\\ 0.46 & 0.44 & 0.50 & 0.48\\ 0.41 & 0.49 & 0.52 & 0.50\end{bmatrix} \quad (24)$$

The parameter formula and the FAHP weight formula can be respectively defined as:

$$g=(N_G-1)/2$$
$$Q=\frac{1}{N_G}-\frac{1}{2g}+\frac{1}{gN_G}\cdot\sum_{l=1}^{N_G}e_{il} \quad (25)$$

Substituting the dimensions N_G=4 of the matrix into formula 25:

$$\lambda=(N_G-1)/2=1.5$$
$$Q_1=\frac{1}{4}-\frac{1}{3}+\frac{1}{6}\cdot(0.50+0.51+0.54+0.59)\approx 0.276$$
$$Q_2=\frac{1}{4}-\frac{1}{3}+\frac{1}{6}\cdot(0.49+0.50+0.56+0.51)\approx 0.263 \quad (26)$$
$$Q_3=\frac{1}{4}-\frac{1}{3}+\frac{1}{6}\cdot(0.46+0.44+0.50+0.48)\approx 0.233$$
$$Q_4=\frac{1}{4}-\frac{1}{3}+\frac{1}{6}\cdot(0.41+0.49+0.52+0.50)\approx 0.240$$

To sum up, the weights of the primary indices are Q_1=0.276, Q_2=0.263, Q_3=0.233, and Q_4=0.240.

Table 2

Importance scores of indices under formation of sports dance awareness

Index	HB_{11}	HB_{12}	HB_{13}	HB_{14}
HB_{11}	0.5	0.49	0.66	0.54
HB_{12}	0.51	0.5	0.51	0.58
HB_{13}	0.34	0.49	0.5	0.32
HB_{14}	0.46	0.42	0.68	0.5

Next, the collected data on the criteria under formation of sports dance awareness were converted against the 9-point scale. Based on the results in Table 2, the fuzzy judgement matrix G_1 of formation of sports dance awareness HB_1 can be obtained as:

$$G_1=\begin{bmatrix}0.5 & 0.63 & 0.56 & 0.48\\ 0.37 & 0.50 & 0.49 & 0.37\\ 0.44 & 0.51 & 0.50 & 0.49\\ 0.52 & 0.63 & 0.51 & 0.50\end{bmatrix} \quad (27)$$

The corresponding fuzzy consistency matrix P_1 can be obtained as:

$$P_1=\begin{bmatrix}0.5 & 0.59 & 0.46 & 0.45\\ 0.41 & 0.50 & 0.53 & 0.39\\ 0.54 & 0.47 & 0.50 & 0.48\\ 0.55 & 0.61 & 0.52 & 0.50\end{bmatrix} \quad (28)$$

Substituting the dimensions $N_{G\text{-}1}$=4 of the matrix into the parameter formula and weight formula:

$$\lambda_1 = (N_{G-1} - 1)/2 = 1.5$$
$$\begin{aligned} Q_{11} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.50 + 0.59 + 0.46 + 0.45) \approx 0.253 \\ Q_{12} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.41 + 0.50 + 0.53 + 0.39) \approx 0.225 \\ Q_{13} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.54 + 0.47 + 0.50 + 0.48) \approx 0.252 \\ Q_{14} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.55 + 0.61 + 0.52 + 0.50) \approx 0.283 \end{aligned} \quad (29)$$

In this way, the index weights under formation of sports dance awareness HB_1 can be obtained as Q_{11}=0.253, Q_{12}=0.225, Q_{13}=0.252, and Q_{14}=0.283.

Table 3

Importance scores of indices under cultivation of sports dance habit

Index	HB_{21}	HB_{22}	HB_{23}	HB_{24}
HB_{21}	0.5	0.6	0.39	0.54
HB_{22}	0.4	0.5	0.59	0.66
HB_{23}	0.61	0.41	0.5	0.51
HB_{24}	0.46	0.34	0.49	0.5

Similarly, the collected data on the criteria under cultivation of sports dance habit were converted against the 9-point scale. Based on the results in Table 3, the fuzzy judgement matrix G_2 of cultivation of sports dance habit HB_2 can be obtained as:

$$G_2 = \begin{bmatrix} 0.50 & 0.60 & 0.39 & 0.54 \\ 0.40 & 0.50 & 0.59 & 0.66 \\ 0.61 & 0.41 & 0.50 & 0.51 \\ 0.46 & 0.34 & 0.49 & 0.50 \end{bmatrix} \quad (30)$$

The corresponding fuzzy consistency matrix P_2 can be obtained as:

$$P_2 = \begin{bmatrix} 0.50 & 0.49 & 0.45 & 0.51 \\ 0.51 & 0.50 & 0.55 & 0.55 \\ 0.55 & 0.49 & 0.50 & 0.53 \\ 0.49 & 0.45 & 0.47 & 0.50 \end{bmatrix} \quad (31)$$

Substituting the dimensions N_{G-2}=4 of the matrix into the parameter formula and weight formula:

$$\lambda_2 = (N_{G-2} - 1)/2 = 1.5$$
$$\begin{aligned} Q_{21} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.50 + 0.49 + 0.45 + 0.51) \approx 0.245 \\ Q_{22} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.51 + 0.50 + 0.55 + 0.55) \approx 0.272 \\ Q_{23} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.55 + 0.49 + 0.50 + 0.53) \approx 0.265 \\ Q_{24} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.49 + 0.45 + 0.47 + 0.50) \approx 0.238 \end{aligned} \quad (32)$$

In this way, the index weights under cultivation of sports dance habit HB_2 can be obtained as Q_{21}=0.245, Q_{22}=0.272, Q_{23}=0.265, and Q_{24}=0.238.

Table 4

Importance scores of indices under mastery of sports dance knowledge

Index	HB_{31}	HB_{32}	HB_{33}
HB_{31}	0.5	0.33	0.55
HB_{32}	0.67	0.5	0.59
HB_{33}	0.45	0.41	0.5

Furthermore, the collected data on the criteria under mastery of sports dance knowledge were converted against the 9-point scale. Based on the results in Table 4, the fuzzy judgement matrix G_3 of mastery of sports dance knowledge HB_3 can be obtained as:

$$G_3 = \begin{bmatrix} 0.50 & 0.33 & 0.55 \\ 0.67 & 0.50 & 0.59 \\ 0.45 & 0.41 & 0.50 \end{bmatrix} \quad (33)$$

The corresponding fuzzy consistency matrix P_3 can be obtained as:

$$P_3 = \begin{bmatrix} 0.50 & 0.46 & 0.50 \\ 0.54 & 0.50 & 0.52 \\ 0.50 & 0.48 & 0.50 \end{bmatrix} \quad (34)$$

Substituting the dimensions N_{G-3}=3 of the matrix into the parameter formula and weight formula:

$$\lambda_3 = (N_{G-3} - 1)/2 = 1$$
$$\begin{aligned} Q_{41} &= \frac{1}{3} - \frac{1}{2} + \frac{1}{3} \cdot (0.50 + 0.46 + 0.50) \approx 0.317 \\ Q_{42} &= \frac{1}{3} - \frac{1}{2} + \frac{1}{3} \cdot (0.54 + 0.50 + 0.52) \approx 0.35 \\ Q_{43} &= \frac{1}{3} - \frac{1}{2} + \frac{1}{3} \cdot (0.50 + 0.48 + 0.50) \approx 0.323 \end{aligned} \quad (41)$$

In this way, the index weights under mastery of sports dance knowledge HB_3 can be obtained as Q_{31}=0.317, Q_{32}=0.35, and Q_{33}=0.323.

Table 5

Importance scores of indices under maintenance of mental health

Index	HB_{41}	HB_{42}	HB_{43}	HB_{44}
HB_{41}	0.5	0.53	0.36	0.53
HB_{42}	0.47	0.5	0.6	0.67
HB_{43}	0.64	0.4	0.5	0.57
HB_{44}	0.47	0.33	0.43	0.5

Finally, the collected data on the criteria under maintenance of mental health were converted against the 9-point scale. Based on the results in Table 5, the fuzzy judgement matrix G_4 of maintenance of mental health HB_4 can be obtained as:

$$G_3 = \begin{bmatrix} 0.50 & 0.53 & 0.36 & 0.53 \\ 0.47 & 0.50 & 0.60 & 0.67 \\ 0.64 & 0.40 & 0.50 & 0.57 \\ 0.47 & 0.33 & 0.43 & 0.50 \end{bmatrix} \quad (33)$$

The corresponding fuzzy consistency matrix P_4 can be obtained as:

$$P_3 = \begin{bmatrix} 0.50 & 0.49 & 0.48 & 0.55 \\ 0.51 & 0.50 & 0.53 & 0.59 \\ 0.52 & 0.47 & 0.50 & 0.57 \\ 0.45 & 0.41 & 0.43 & 0.50 \end{bmatrix} \quad (34)$$

Substituting the dimensions N_{G-4}=4 of the matrix into the parameter formula and weight formula:

$$\lambda_4 = (N_{G-4} - 1)/2 = 1.5$$
$$\begin{aligned} Q_{41} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.50 + 0.49 + 0.48 + 0.55) \approx 0.256 \\ Q_{42} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.51 + 0.50 + 0.53 + 0.59) \approx 0.275 \\ Q_{43} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.52 + 0.47 + 0.50 + 0.57) \approx 0.263 \\ Q_{44} &= \frac{1}{4} - \frac{1}{3} + \frac{1}{6} \cdot (0.45 + 0.41 + 0.43 + 0.50) \approx 0.218 \end{aligned} \quad (37)$$

In this way, the index weights under maintenance of mental health HB_4 can be obtained as Q_{41}=0.256, Q_{42}=0.275,

Q_{43}=0.263, and Q_{44}=0.218.

Experiments and Results Analysis

The previous research has carried out experiments on the following issues of seniors: the satisfaction of basic psychological needs, self-determination motives, and physical exercise behaviors, as well as the relationship between the three issues. This paper expands the scope and strategy of the relevant research through a synthetic discussion of the three issues.

The weights of primary indices and criteria obtained above were synthetized into the composite weight of each criteria. The weight distribution of the EIS for the mental health of seniors in sports dance is summarized in Table 6.

Table 6

Weight distribution of the EIS

Goal	Primary index	Weight	Criterion	Weight	Composite weight
Evaluation of mental health of seniors in sports dance	HB_1	0.276	HB_{11}	0.253	0.0698
			HB_{12}	0.225	0.0621
			HB_{13}	0.252	0.0695
			HB_{14}	0.283	0.0781
	HB_2	0.263	HB_{21}	0.245	0.0644
			HB_{22}	0.272	0.0715
			HB_{23}	0.265	0.0696
			HB_{24}	0.238	0.0625
	HB_3	0.233	HB_{31}	0.317	0.0738
			HB_{32}	0.35	0.0815
			HB_{33}	0.323	0.0752
	HB_4	0.24	HB_{41}	0.256	0.0614
			HB_{42}	0.275	0.0660
			HB_{43}	0.263	0.0631
			HB_{44}	0.218	0.0523

This paper designs five levels for the evaluation of mental health of seniors in sports dance: {very high, high, general, low, very low}; {very good, good, general, poor, very poor}. The comment set of each criterion is shown in Table 7.

Table 7

Comment set of each criterion

Criterion	Level 1	Level 2	Level 3	Level 4	Level 5
HB_{11}	Very high	High	General	Low	Very low
HB_{12}	Very high	High	General	Low	Very low
HB_{13}	Very good	Good	General	Poor	Very poor
HB_{14}	Very high	High	General	Low	Very low
HB_{21}	Very good	Good	General	Poor	Very poor
HB_{22}	Very high	High	General	Low	Very low
HB_{23}	Very high	High	General	Low	Very low
HB_{24}	Very good	Good	General	Poor	Very poor
HB_{31}	Very good	Good	General	Poor	Very poor
HB_{32}	Very good	Good	General	Poor	Very poor
HB_{33}	Very good	Good	General	Poor	Very poor
HB_{41}	Very good	Good	General	Poor	Very poor
HB_{42}	Very good	Good	General	Poor	Very poor
HB_{43}	Very good	Good	General	Poor	Very poor
HB_{44}	Very good	Good	General	Poor	Very poor

Then, a questionnaire was designed based on the comment set of each criterion and distributed to experienced experts in psychological field. These experts judged the levels of the primary indices, and the criteria in our EIS. After receiving the feedbacks of the survey, the levels assigned by the experts to the criteria were converted into membership. Table 8 lists the membership of the evaluation indices. Figure 3 is the scree plot of the criteria.

Table 8

Membership of the evaluation indices

Primary index	Criteria	Membership
HB_1 (0.276)	HB_{11} (0.253)	(0.4, 0.5, 0.4, 0, 0)
	HB_{12} (0.225)	(0.3, 0.6, 0.4, 0, 0)
	HB_{13} (0.252)	(0.4, 0.6, 0.3, 0, 0)
	HB_{14} (0.283)	(0.3, 0.2, 0.3, 0, 0)
HB_2 (0.263)	HB_{21} (0.245)	(0.3, 0.7, 0.3, 0, 0)
	HB_{22} (0.272)	(0.3, 0.8, 0.2, 0, 0)
	HB_{23} (0.265)	(0.40.5, 0.4, 0, 0)
	HB_{24} (0.238)	(0.3, 0.3, 0.7, 0, 0)
HB_3 (0.233)	HB_{31} (0.317)	(0.5, 0.5, 0.3, 0, 0)
	HB_{32} (0.35)	(0, 0.4, 0.4, 0.3, 0.3)
	HB_{33} (0.323)	(0, 0.3, 0.6, 0.3, 0.2)
HB_4 (0.24)	HB_{41} (0.256)	(0, 0.2, 0.6, 0.4, 0.2)
	HB_{42} (0.275)	(0.4, 0.3, 0.3, 0.2, 0)
	HB_{43} (0.263)	(0.3, 0.4, 0.5, 0.2, 0)
	HB_{44} (0.218)	(0.4, 0.4, 0.6, 0.2, 0)

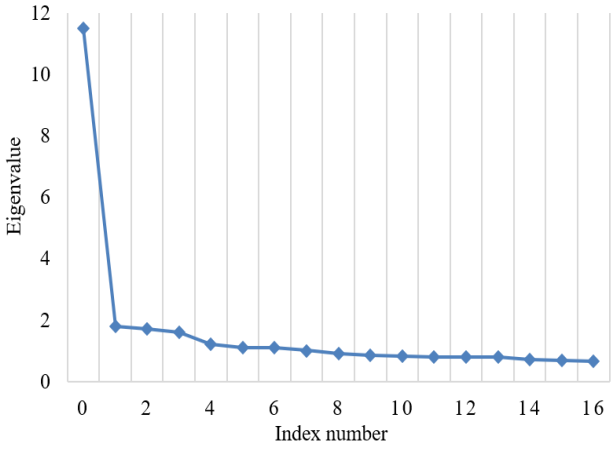

Figure 3. Scree plot of the criteria

Table 9 presents the gender difference of the improving effect of sports dance on seniors' mental health. It can be inferred that, there was a certain difference between male and female seniors in terms of the degree of improvement to mental health under the intervention of sports dance. The improving effect of males was stronger than that of

females in four dimensions: loneliness, decadence, worry, and inappetence; the improving effect of females was stronger than that of males in the other dimensions. It can also be seen that the gender difference in mental health improvement was significant in three dimensions only: sentimentality, overwork, and irritability (p≥0.05).

Table 9

Gender difference of the improving effect of sports dance on seniors' mental health

Type	Males	Females	t	p
Loneliness	4.92±0.95	4.21±0.63	5.176	0.053
Boredom	4.25±0.73	4.41±0.96	3.415	0.062
Decadence	3.72±0.67	3.71±0.67	1.414	0.165
Suspicion	4.92±0.85	4.96±0.81	1.632	0.112
Encumbrance	5.01±1.034	5.02±1.036	0.184	0.862
Desperation	3.21±0.52	3.24±0.33	1.863	0.072
Sentimentality	3.02±0.68	3.84±0.56	2.547	0.013*
Nostalgia	3.01±0.72	3.08±0.58	-1.532	0.135
Sadness	2.52±0.73	2.54±2.55	-0.589	0.541
Worry	2.81±0.54	2.71±0.34	-1.843	0.062
Inappetence	4.07±0.63	3.28±0.63	0.547	0.572
Agitation	3.22±0.85	3.31±0.64	4.623	0.042
Overwork	3.42±0.84	3.28±0.62	3.962	0.000**
Depression	3.73±0.76	3.67±0.65	2.865	0.032
Irritability	3.09±0.66	3.13±0.54	-1.794	0.002*

Table 10 presents the gender difference of the improving effect of sports dance on seniors' subjective happiness. It can be observed that male seniors differed significantly from female seniors in mental health and the willingness for sports dance (t=3.549, p=0.000347; t=2.932, p=0.004). The males were much better in mental health and stronger in the willingness for sports dance than females.

Table 10

Gender difference of the improving effect of sports dance on seniors' subjective happiness

Type	Males	Females	t	p
Mental health	126.68±17.36	115.42±16.54	3.549	0.000347*
Willingness for sports dance	227.25±27.03	228.76±17.09	2.932	0.004*
Subjective happiness	143.31±16.85	136.92±13.26	2.567	0.038*

Table 11 presents the regional difference of the improving effect of sports dance on seniors' mental health. It can be seen that, urban seniors were lower than rural ones in all dimensions: loneliness, boredom, decadence, suspicion, encumbrance, desperation, sentimentality, nostalgia, sadness, worry, inappetence, agitation, overwork, depression, and irritability. It can also be learned that urban and rural seniors only have significant differences in the improving effect on four dimensions of mental health: loneliness, desperation, inappetence, and depression (p≥0.05).

Table 11

Regional difference of the improving effect of sports dance on seniors' mental health

Type	Urban	Rural	t	p
Loneliness	3.09±0.63	3.42±0.75	-5.242	0.000**
Boredom	2.54±0.65	2.56±0.74	-0.019	0.975
Decadence	2.76±0.42	2.83±0.56	-1.572	0.131
Suspicion	4.03±0.51	4.19±0.61	-0.843	0.476
Encumbrance	3.44±0.72	3.54±0.85	-1.954	0.058
Desperation	3.36±0.79	3.51±0.82	-2.467	0.016*
Sentimentality	3.65±0.63	3.76±0.74	-1.734	0.095
Nostalgia	3.13±0.54	3.05±0.73	0.642	0.563
Sadness	2.98±0.62	3.02±0.78	-1.712	0.081
Worry	4.75±0.94	4.81±1.09	-1.974	0.052
Inappetence	4.12±0.68	4.27±0.88	-2.165	0.036*
Agitation	4.83±0.76	5.07±0.94	-1.832	0.065
Overwork	5.04±0.92	5.06±1.17	0.167	0.872
Depression	3.42±0.42	3.62±0.43	-3.845	0.000**
Irritability	2.54±0.86	2.65±1.08	-1.057	0.284

Table 12 presents the regional difference of the improving effect of sports dance on seniors' subjective happiness. It can be observed that urban seniors differed significantly from rural seniors in subjective health and the willingness for sports dance (t=3.872, p=0.0001; t=2.342, p=0.018). The urban seniors were much better in mental health and stronger in the willingness for sports dance than rural ones.

Table 12

Regional difference of the improving effect of sports dance on seniors' subjective happiness

Type	Rural	Urban	t	p
Mental health	124.34±15.71	125.93±19.34	1.843	0.050
Willingness for sports dance	224.72±23.85	236.72±28.63	2.342	0.018
Subjective happiness	138.36±15.62	145.52±17.52	3.872	0.001**

Conclusions

This paper probes into the cultivation and differential development of mental health and subjective happiness of seniors based on sports dance. After setting up a scientific EIS, a matter-element extension model was provided, along with the detection method for indices. Then, each index was assigned with a suitable weight. After that, experiments were carried out to obtain the weight distribution of the EIS, the comment set of each criterion, and the membership of the indices. Based on experimental results, the authors summarized the gender and regional differences of the

improving effect of sports dance intervention on seniors' mental health and objective happiness.

Limitations and Future Directions

This paper faces several limitations. First, this research, as a profile survey, does not fully expound the causality between the satisfaction of basic psychological needs, self-determination motives, and physical exercise behaviors. Second, the sample size, i.e., the number of seniors in the study area, is severely limited, due to the constraint of objective factors.

Based on this paper, further research could resort to longitudinal intervention experiment to study the generation and maintenance of sports dance exercise among seniors in the community, observe the relationship between variables, and observe the increase of seniors' physical exercise under different mental states in realistic scenarios.

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