Research on Flexibility Test of Aerobics Staff Based on Discrete Differential Algorithm

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Objectives: With the development of economy and the improvement of people's life quality, people are paying more and more attention to their own health condition..Methods: For aerobics personnel, they often have higher requirements on flexibility, and put forward the flexibility of aerobics personnel based on discrete differential algorithm testing research .Through literature comparative analysis, the basic concepts of fractional Fourier transform are expounded. The basic principle of discrete sampling algorithm of DFRFT is analyzed. The realization steps of dimension normalization are designed and applied in case analysis.. Results:The study found that this algorithm has a strong versatility and a moderate amount of calculation, which can be applied to most of the flexibility testing,Conclusion: providing a theoretical basis for the future detection methods of people's health.

Keywords:discrete algorithm; aerobics personnel; flexibility; testing research
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In today's society, the economy is developing and the quality of people's life is improving. People are paying more and more attention to their own health. The word "fitness" was first introduced into English from the Mainland and then inland from Hong Kong and Taiwan [1]. Physical fitness can be divided into physical fitness and athletic fitness, and human health status, work and working ability and the level of competitive sports are closely related [2]. Among them, the health fitness and human health are most closely related to the human body composition, cardiorespiratory endurance, strength and muscle endurance and flexibility were assessed. Aerobics is a blend of "health" and "beauty" as one, combining dance, sports and other forms of exercise [3]. Aerobics sprout in the early 60s of the 20th century, so far only 40 years of history. It was through this competition that the United States held the Aerobics Classics Competition in 1985. Aerobics quickly became a worldwide sport. Flexibility refers to the magnitude of human joint activity and the elasticity and extensibility of the ligaments, tendons, muscles, skin and other tissues across the joint [4] The poor flexibility of the joints of the whole body will affect the mastery of movements and the exertion of technology. The degree of flexibility affects the range of joint activities, the range of contraction of muscles and the risk of injury. At the same time, the level of flexibility in Aerobics students of the College of education has a direct impact on the development prospect and direction of this sport in the Education Institute[5].

The problem of numerical differentiation is to find the approximate value of the function derivative by measuring the value of the function at some discrete points. In many practical problems, the problem of obtaining the derivative of the approximate function, such as the identification of the diffusion coefficient in the heat conduction equation; the image processing In the boundary identification problem of integral equation of the problem; chemical peaks in the spectrum identification problems; mechanics of the relationship between force and torque; corrosion detection and mathematical physics equations in some of the inverse problem [6]. Compared with other inverse problems, the problem of numerical differentiation is an old problem. Since the middle of the last century, many scholars at home and abroad have conducted research on this subject and obtained rich scientific research results. If the theoretical research does not consider the data Error, using the general finite difference method can be obtained approximate derivative [7]. Many people have studied the convergence of the finite difference method, but if the data with errors, using the finite difference method may result in a large numerical error of the solution are usually divided by the spacing cannot be too small solution, That is, the measurement point cannot be too much. Under this condition, the calculation result is acceptable. Otherwise, it is possible that the more the measurement point is, the worse the result is. However, this requirement is not in line with people's thinking habits [8]. People habitually think that more data can help to get more accurate results. Another way to solve numerical differentiation is to use the regularization method. This method is the most complete and practical in theory to solve ill-posed questions and reverse questions Effective[9].

METHODS

Fractional Fourier Transform the Basic Concepts

In general, the p -order fractional transformation of the $x(t)$ -function can be expressed as $X_p(u)$ or $F^p x(t)$ as needed. $F^p x(t)$ can be regarded as operator F^p acting on signal $x(t)$.

In the following, the basic definition of Fractional Fourier Transform is given from the perspective of linear transformation. The $x(t)$ -order fractional Fourier transform of the function p defined in the time domain is a linear operation.

$$X_p(u) = \int_{-\infty}^{+\infty} \tilde{K}_p(u,t)x(t)dt \quad (1)$$

Where

$$\tilde{K}_p(u,t) = A_\alpha \exp[j\pi(u^2 \cot\alpha - 2ut\csc\alpha + t^2\cot\alpha)]$$

, $\tilde{K}_p(u,t)$ is called the fractional Fourier transform of the kernel function, where: $A_\alpha = \sqrt{1 - j\cot\alpha}$, $\alpha = p\pi/2$, $p \neq 2n$, n are integers.

Substituting variables $u = u/\sqrt{2\pi}$ and $t = t/\sqrt{2\pi}$ by (2-6) can be further expressed as:

$$X_p(u) = \{F^p[x(t)]\}(u) = \int_{-\infty}^{+\infty} K_p(u,t)x(t)dt \quad , \quad 0 < |p| < 2 \,, \; 0 < |\alpha| < \pi$$

$$= \begin{cases} B_\alpha \int_{-\infty}^{+\infty} \exp\left(j\dfrac{t^2+u^2}{2}\cot\alpha - \dfrac{jtu}{\sin\alpha}\right)x(t)dt & \alpha \neq n\pi \\ x(t) & \alpha = 2n\pi \\ x(-t) & \alpha = (2n+1)\pi \end{cases} \quad (2)$$

Among them, $B_\alpha = \sqrt{\dfrac{1 - j\cot\alpha}{2\pi}}$. The definition of fractional Fourier transform given in Eq. (2) is linear, but it does not mean that it is invariant except $(p = 4n)$, since the kernel function is not only a function of (u,t), but also a function of order p . Right p = 1, there $\alpha = \pi/2$, $A_\alpha = 1$, and

$$X_1(u) = \int_{-\infty}^{\infty} x(t)e^{-j2\pi ut}dt \quad (3)$$

Can be seen, $X_1(u)$ is $x(t)$ ordinary Fourier transform. It can also be seen that $X_1(u)$ is the inverse of the traditional Fourier transform of $x(t)$. Because $\alpha = p\pi/2$ can only appear in the trigonometric function parameter position, so the definition of p as a parameter is based on 4 cycles, so only need to examine the interval $p \in (-2,2]$ can be. When $p = 0$, $f_0(u) = f(u)$; when $p = \pm 2$, $f_{\pm 2}(u) = f(-u)$.

The above facts are expressed by operators as follows:

$$\begin{aligned} F^0 &= I \\ F^1 &= F \\ F^2 &= P \\ F^3 &= FP = PF \\ F^4 &= F^0 = I \\ F^{4n \pm p} &= F^{4n' \pm p} = F^{\pm p} \end{aligned} \quad (4)$$

Where, A and B are arbitrary integers.

Fractional order additivity is a very important property of fractional Fourier transform, which can be expressed as:

$$F^{p_1} F^{p_2} = F^{p_1 + p_2} = F^{p_2} F^{p_1} \quad (5)$$

This property can be proved by reusing the equation (2-1), but the square root of the coefficient A_α complicates the process. The use of direct integrals by applying Gaussian integration makes the operation easier, namely:

$$\int K_{p_2}(u,u') K_{p_1}(u,u') du' = K_{p_1 + p_2}(u,t) \quad (6)$$

To sum up, we can make the first interpretation of Fractional Fourier Transform. That is to say, only $0 \le p \le 1$ interval is considered, Fractional Fourier Transform is the original function, and when $p = 1$, Fractional Fourier Transform is normal Fourier Litter transforms. When p gradually changes from 0 to 1, its fractional Fourier transform smoothly changes from the original function to the general Fourier transform.

Fractional Fourier transform can also be defined as the rotation of the time-frequency plane, the p-order fractional Fourier transform is a linear regular transformation defined by the transformation matrix, and the transformation matrix is:

$$M = \begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cos\alpha & \sin\alpha \\ -\sin\alpha & \cos\alpha \end{bmatrix} \quad (7)$$

Among them, $\alpha = p\pi/2$. According to the Radon transform (linear integration of f (x, y) along different lines in a plane (the distance between the straight line and the origin is d and the direction angle is α), the resulting image $F(d,\alpha)$ is a Radon transform of the function) The matrix is considered as a two-dimensional rotation matrix on the time-frequency plane.

DFRFT Discrete Algorithm

By directly sampling the continuous fractional Fourier transform kernel, we can get the DFRFT kernel matrix. The main factor to consider for this type of DFRFT is the fractional Fourier transform numerical calculation. Since this is only an interest in the method of calculating continuous fractional Fourier transforms, the DFRFT in this case is required to approximate a continuous fractional Fourier transform, with the expectation that the defined DFRFT algorithm has a fast algorithm. Under normal circumstances, DFRFT discretization algorithm has the following three ways [10].

The first one: DFRFT is defined by sampling directly in the signal's time domain and fractional Fourier domain:

$$X_\alpha(kF) = A_\alpha e^{j\frac{1}{2}(kF)^2 \cot\alpha} \sum_{n=0}^{N-1} x(nT) e^{j\frac{1}{2}(nT)^2 \cot\alpha - j(\frac{2\pi}{N})nk} \quad (8)$$

Where T is the time-domain sampling interval, and $F = 2\pi/(NT\csc\alpha)$ is the sampling interval of the fractional-order Fourier domain.

The second one: This method samples the time domain of the original function N points and maps it to N sampling points in the fractional Fourier domain. It is worth noting that the computational complexity of this algorithm is O(N log N), to meet the needs of the rapid calculation of the actual project.

The third one: This algorithm separately for continuous fractional Fourier transform in the time domain and fractional Fourier domain, select the appropriate sampling interval, DFRFT to meet the orthogonality and reversibility. It is noteworthy that the DFRFT algorithm has lower computational complexity than Ozaktas' DFRFT algorithm.

Focus on the second algorithm introduced. In this method, N points are sampled in the time domain of the original function, and mapped into N sampling points in fractional Fourier domain. The computational complexity of the algorithm is O(N log N). Before using this method to calculate Fractional Fourier Transform, the original signal must be dimension normalized. After dimension normalization, the signal is dimensionless in time domain and frequency domain, and the support length in both time domain and frequency domain are equal. This also shows that the Wigner distribution of the signal is limited to the unit circle centered at the radius and time-frequency plane origin. In order to obtain efficient calculation method, the calculation of fractional Fourier transform is decomposed into convolutional form here. According to the definition of fractional Fourier transform, the fractional order Fourier transform of the signal can be written as:

$$X_\alpha(u) = A_\alpha e^{-j\frac{1}{2}u^2\tan(\frac{\alpha}{2})}\int_{-\infty}^{\infty}[x(t)e^{-j\frac{1}{2}t^2\tan(\frac{\alpha}{2})}]e^{j\frac{1}{2}(u-t)^2\csc\alpha}dt \quad (9)$$

From (9), we can see that the calculation of Fractional Fourier Transform can be decomposed into three steps.

In the first step, the signal $x(t)$ is multiplied by a chirp function and the resulting intermediate result is recorded as g(t). By this operation, the frequency domain bandwidth of g(t) becomes the frequency domain of signal $x(t)$ the bandwidth of 2 times, so g(t) sampling interval should be $1/2\Delta x$. However, if the sampling interval of the original signal $x(t)$ is $1/\Delta x$, if the sampling interval of $x(t)$ is to be changed to $1/2\Delta x$ at this time, it is necessary to perform 2 times interpolation on the signal $x(t)$ to obtain the sampling interval Signal $x(t)$, and then multiplies the intermediate signal g(t) with the sampling interval $1/2\Delta x$.

In the second step, the signal g(t) is convoluted with a chirp signal because the bandwidth of g (t) is $2\Delta x$. Thus, according to the convolution theorem, the chirp signal can be represented by its band-limited form of $2\Delta x$, denoted by h (t).

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$$h(t) = \int_{-\Delta x}^{\Delta x} H(\Omega)e^{j\Omega t}d\Omega \quad (10)$$

Where $H(\Omega)$ is the Fourier transform of the convolution chirp signal.

Write convolutions in discrete form,

$$g'(\frac{m}{2\Delta x}) = \sum_{n=-N}^{N} h(\frac{m-n}{2\Delta x})g(\frac{n}{2\Delta x}) \quad (11)$$

This convolution formula can use FFT to calculate.

The third step is to multiply another chirp signal, which gives 2N sampling points with $X_\alpha(u)$'s sampling interval of $1/2\Delta x$. Because it is a mapping of N sampling points in the time domain to N sampling points in the fractional Fourier domain, extracting C twice as much as $X_\alpha(u)$ can obtain a $1/\Delta x$ sample with a sampling interval of $X_\alpha(u)$.

Let X_α and x denote column vectors consisting of N samples of $X_\alpha(u)$ and x(t), respectively, then the above calculation can be written in matrix form:

$$X_\alpha = F_I^a x, \quad (12)$$

$$F_I^a = D\Lambda H\Lambda J, \quad (13)$$

Where D and J represent decimation and interpolation operations, Λ and H correspond to chirp multiplication and chirp convolution operations, respectively.

The above is the first method of representing a fractional Fourier transform as a convolution operation. Fractional Fourier transforms can also be represented as another form:

$$X_\alpha(u) = A_\alpha e^{j\frac{1}{2}u^2(\cot\alpha-\csc\alpha)}\int_{-\infty}^{\infty}[x(t)e^{j\frac{1}{2}t^2(\cot\alpha-\csc\alpha)}]e^{j\frac{1}{2}(u-t)^2\csc\alpha}dt \quad (14)$$

The formula (14) is sampled:

$$X_\alpha(\frac{m}{2\Delta x}) = A_\alpha e^{j\frac{1}{2}(\frac{m}{2\Delta x})^2(\cot\alpha-\csc\alpha)} \sum_{n=-N}^{N} [x(\frac{n}{2\Delta x})e^{j\frac{1}{2}(\frac{n}{2\Delta x})^2(\cot\alpha-\csc\alpha)}]e^{j\frac{1}{2}(\frac{m-n}{2\Delta x})^2\csc\alpha} \quad (15)$$

The sum of (15) can be expressed as a convolution of the signal, using FFT. Finally, the $X_\alpha(u)$ is extracted twice, you can get $1/\Delta x$ as the sampling interval of $X_\alpha(u)$ samples. Similarly, the above sampling process can be expressed in matrix form as:

$$X_\alpha = F_{II}^{a} x \quad (16)$$

$$F_{II}^{a} = DK_a J \quad (17)$$

Among them:

$$K_a(m, n) = A_\alpha e^{j\frac{1}{2}(\frac{m}{2\Delta x})^2(\cot\alpha-\csc\alpha)-j\frac{1}{2}(\frac{n}{2\Delta x})^2(\cot\alpha-\csc\alpha)+j\frac{1}{2}(\frac{m-n}{2\Delta x})^2\csc\alpha} \quad (18)$$

Dimensional Normalized Processing

Since the original signal has different dimensions in the time and frequency domains and the scales between them are not uniform, we need to measure the original signal before calculating the fractional Fourier transform of the original signal Outline normalization, dimensional normalization of the FRFT discrete realization has played an important role.

Investigate the $\exp(j\pi t^2 \cot\alpha)$ distribution of the chirp signal $Wingner-Ville$ in the time-frequency plane. $Wingner-Ville$ distribution is defined as:

$$W_x(t, f) = \int_{-\infty}^{+\infty} e^{-j2\pi f\tau} x(t+\frac{\tau}{2})x^*(t-\frac{\tau}{2})d\tau \quad (19)$$

The $Wingner-Ville$ distribution of Chirp function $\exp(j\pi t^2 \cot\alpha)$ is:

$$W_{chirp}(t, f) = \int_{-\infty}^{+\infty} e^{-j2\pi f\tau} \exp[j\pi\cot(t+\frac{\tau}{2})^2]\exp[-j\pi\cot\alpha(t-\frac{\tau}{2})^2]d\tau$$

$$= \int_{-\infty}^{+\infty} \exp[-j2\pi(f-\cot\alpha\cdot t)\tau]d\tau = \delta(f-\cot\alpha\cdot t) \quad (20)$$

Equation (20) shows that the $Wingner-Ville$ distribution of chirp function $\exp(j\pi t^2 \cot\alpha)$ must satisfy condition $Wingner-Ville$. Due to the frequency f and time t different dimensions, cannot meet the above conditions. Therefore, before calculating the DFRFT using the decomposition method, we must first normalize the frequency f and the time t. After the dimension normalization, the chirp function has a normalized width Δx in the v domain and a normalized width $\cot\alpha\cdot\Delta x$ in the domain.

When the discrete signal is normalized by scaling, the appropriate time-width t_b, bandwidth f_b, scale factor S and normalized width x_b should be selected first, so that the data obtained after scaling the discrete signal is scaled to the original continuous signal. After normalized by scale conversion, the data obtained after $1/x_b$ sampling at the sampling interval is the same.

The time width of the signal is directly taken as the observation time t_0, that is, $t_b = t_0$, the time domain of the signal is limited to the area $[-t_0/2, t_0/2]$. The exact bandwidth of the signal is not clear, but the sampling frequency f_s is known in practical engineering. The sampling theorem, the sampling frequency more than 2 times the maximum frequency of the signal. Bandwidth f_b does not require a minimum value. It suffices to include the entire energy of the signal in the bandwidth. It is appropriate to take the bandwidth directly as the sampling frequency, that is, $f_b = f_s$, and the frequency domain of the signal is limited to the interval $[-f_s/2, f_s/2]$. After the time width and bandwidth of the signal are determined, the scalefactor S and the normalized width S are respectively [5] [5]:

$$S = (t_b / f_b)^{1/2} = (t_0 / f_s)^{1/2}, \quad (21)$$

$$x_b = (t_b f_b)^{1/2} = (t_0 f_s)^{1/2} \quad (22)$$

Discrete signal sampling interval of the original $t_s = 1/f_s$, the scale of the discrete signal scale conversion for the scale, the sampling interval becomes:

$$t_s' = (t_0 f_s)^{-1/2} = 1/x_b \quad (23)$$

After scaling, the original time-domain interval $[-t_0/2, t_0/2]$ becomes $[-x_b/2, x_b/2]$, so we can say that the discrete scaling method is based on the sampling rate of bandwidth, the observation time is wide, the scaling of discrete data scaling, the realization of dimension Normalized.

RESULTS

Experimental Results Analysis

In sports science, flexible primary fitness refers to the human skeletal muscle system characteristic that determines the maximum activity range of a single joint or a group of joints, without causing physical injury, also called flexibility. Early studies suggest that Routon has both static and dynamic manifestations, and therefore uses static flexibility and dynamic flexibility to distinguish between these two manifestations. Later, however, the study found that the rebound or oscillatory stretching exercises used in dynamic compliance testing are more about speed, coordination and strength than about flexibility, so what is currently being used by academia.The connotation of the concept of dynamic flexibility has undergone fundamental changes. At present, the basis for distinguishing between static flexibility and dynamic flexibility of flexibility is the difference in biomechanical measurement methods of early softness. Among the health-related fitness components, flexibility and fitness are the most easily overlooked by physical exercisers, health-fitness researchers, and others. It is generally believed that developing and maintaining flexibility is important for improving athletic performance and preventing injuries, but its health implications remain unclear. So this article selects the sitting position forward flexion, the standing body forward flexion, the rotation shoulder test, the prone back extension and so on several soft initial indicators, carries on the softness evaluation to the foreign affairs college, the political science and law university two universities' calisthenics. The measured data are analyzed, and the results are shown in figures 1 and 2.

Figure 1
Statistics of Male Sex Test Indicators

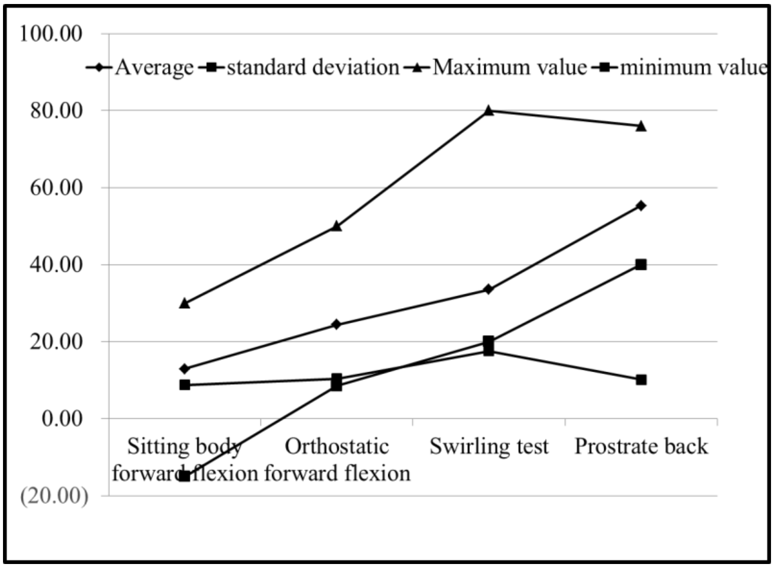
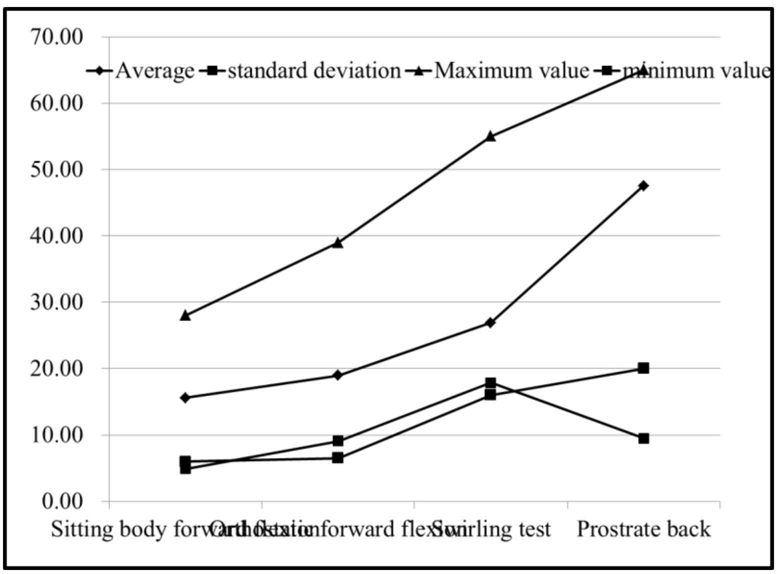


Figure 2
Statistics of Women's Soft Initial Test Index



As the figure shows, sitting body flexion, standing body flexion, spin shoulder test and prone stretch these four indicators are quiet and flexible quality measurement and evaluation. According to the Chinese Constitutional Health Center sitting on the body flexion set standards, the provisions of the boys around 23 is excellent, 18.9-12.5 is good, 2.4 or less failed; girls around 21.1 is excellent, 1.7-11.3 is good, 1.5 the following failed. According to the test results of male and female sitting anterior body flexion, the maximum value of male and female sitting anterior flexion both surpassed the excellent value of sitting flexion given by China Physical Fitness Center. The minimum value of female students was within the range of passing standards, but the minimum for boys is far beyond the standard of failing given by China Physical Health Center. It can be seen that the experimental students waist, hip, knee and other joints of the soft initial good, but some boys cannot rule out the softness of these several factors, so in teaching should be strengthened on the flexibility of boys Practice.

Through the analysis of the results of four test indexes of softness test and the normal distribution test, it is found that only the three test indexes of sitting body forward flexion, standing body flexion and prone back stretch are normal distribution, while the rotation shoulder test Was skewed distribution, so screening out the test index, now flexibility of the four test indicators for factor analysis.

Flexibility Test Indicators Factor Analysis

Table 1
Male Test Index Contribution Rate Table

factor	Initial eigenvalue			Extracting square sum and loading		
	Total	Variance%	Cumulative degree%	Total	Variance%	Cumulative degree%
1	2.805	46.789	46.789	2.805	46.789	46.789
2	1.768	29.453	76.103	1.768	29.453	76.103
3	.875	14.548	90.474	-	-	-
4	.315	5.314	95.975	-	-	-

Table 2
Female Test Index Contribution Rate Table

factor	Initial eigenvalue			Extracting square sum and loading		
	Total	Variance%	Cumulative degree%	Total	Variance%	Cumulative degree%
1	2.456	41.131	41.131	2.456	41.131	41.131
2	1.952	32.456	72.348	1.952	32.456	72.348
3	.859	14.588	86.542	-	-	-
4	.579	9.654	96.472	-	-	-

As can be seen from Tables 1 and 2, the initial eigenvalues of the four indicators of the boys' flexible qualities are greater than those with two components, and two common factors are extracted with a cumulative contribution rate of 76.1%. There are two components of the four eigenvalues of girls with flexible qualities, two common factors are extracted, and the cumulative contribution rate is 72.3%.

Table 3
Male Composition Matrix

Sitting body forward flexion	Orthostatic forward flexion	Prostrate back
0.826	-.856	.357

Table 4
Female Composition Matrix

Sitting body forward flexion	Orthostatic forward flexion	Prostrate back
0.664	0.645	0.196

It can be seen from the factor analysis in Tables 1 and 2, above that the eigenvectors of male and female students whose absolute value is larger than 2 in the factor are both sitting anterior body flexion and erecting anterior body flexure, which are the indicators of flexibility. Through the table of indicators of contribution rate table and component analysis table can be drawn, the factor is flexible factor. In this factor, the boys and girls respectively have two indexes, sitting forward flexion and standing forward flexion. In order to make the selected index scientific and reasonable, the correlation analysis between selected indexes is made.

DISCUSSION

With the development of economy and improvement of people's life quality, people's movement patterns are more and more diversified. Aerobics is a flexible and diverse movement with more body parts involved, which produces different fitness effects on body parts. There are many factors that contribute to the flexibility of aerobics, such as the excitability of the central nervous system, the temperature of the external environment, the size of muscle mass, and the accumulation of fat. Based on this, this paper proposed a study on the flexibility testing of aerobics personnel based on discrete differential algorithm, and focused on the basic theory of Fractional Fourier Transform and the realization of discretization algorithm. The research shows that the flexibility of the experimenter is in good condition through the factor analysis and the discrete sampling algorithm. The flexion of the standing body and the flexion of the sitting body were the test indexes of the flexibility of aerobics personnel. The experimental test, the algorithm test high accuracy, strong anti-interference, the amount of calculation is moderate, has strong versatility, to meet the needs of real-time testing for the future of all types of athletes, physical fitness test analysis pointed out the direction of development.

Human Subjects Approval Statement

This paper did not include human subjects.

Conflict of Interest Disclosure Statement

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