

# Model of Imitation of Long-term Adaptations by Prof. V.N. Seluyanov

Nine ODEs, three muscle contraction regimes, an adaptation forecast for any horizon from 1 to 365 days — with the impact of the ration and nutrition regime.

## 1. Introduction

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MIDA (Model of Imitation of Long-term Adaptations) is a computerized mathematical model of long-term adaptation to physical load developed by Prof. V.N. Seluyanov and adapted for the Samson-fit ecosystem.

The model is the scientific core of the adaptation forecast service: it converts a training plan and nutrition data into trajectories of structural adaptation — myofibril mass (mf) and mitochondria mass (mx).

Forecast horizon: 90 days by default. The user can set any horizon from 1 to 365 days with one-day precision; the Optimizer works with horizons of 30–365 days.

All three muscle contraction regimes are supported: isometric (native for the model), dynamic (concentric) and eccentric.

## 2. Theoretical foundations

### 2.1. Supercompensation principle

Training load destroys part of the cellular structures (myofibrils, mitochondria). Recovery not only restores the baseline but may exceed it — supercompensation. Repeating the load at the supercompensation peak drives structural growth; premature or delayed loads accumulate fatigue instead of growth.

### 2.2. Dosage principle

MIDA formalizes this rule: the growth stimulus depends on the intensity share above the stress threshold (the ANP for mitochondria, about 30% of MVC for myofibrils), on the session duration and on the recovery interval between sessions. Too high an intensity without sufficient recovery degrades structures.

### 2.3. Exercise load characteristics (formulas (2.7)-(2.11))

Seluyanov's original model considers the influence of an exercise as a simple function of  $P_{rel} \times t \times n$ . However, the same exercise performed with different techniques can produce significantly different training effects. Real exercises possess biomechanical characteristics that substantially modify the training stimulus.

For example, barbell squats and bench press with the same  $P_{rel}$ ,  $t$  and  $n$  affect the same muscle groups differently: squats engage more muscle fibers through a larger range of motion, while bench press localizes the load on the pectorals and triceps. Accounting for these differences requires introducing correction coefficients.

Extended exercise influence function:

$$B_{i,j} = P_{rel} \times t \times n \times k_i \times K_{biomech,j,i} \times K_{phase,j,i}(\varphi) \times K_{tempo,j} \times K_{ampl,j} \times K_{vib} \quad (2.7)$$

where  $K_{\text{biomech},j,i}$  is the biomechanical correction coefficient for exercise  $j$  on system  $i$  (depends on joint angles, force arms, lever ratios). Value range: 0 to 1.

$K_{\text{phase},j,i}(\varphi)$  — phase correction coefficient at phase  $\varphi$  of exercise  $j$  for system  $i$ . It accounts for the fact that different muscles contribute differently at different phases of the exercise.

$K_{\text{tempo},j}$  — tempo correction coefficient (depends on the durations of eccentric, isometric, and concentric phases).

$K_{\text{ampl},j}$  — amplitude/range of motion correction coefficient.

### Biomechanical coefficient $K_{\text{biomech}}$

The biomechanical coefficient is determined by the ratio of the muscle force moment in a given exercise to the maximum possible moment and by the angular dependence:

$$K_{\text{biomech},j,i} = (M_{j,i} / M_{i,\text{max}}) \times \cos(\theta_{j,i} - \theta_{i,\text{opt}}) \quad (2.8)$$

where  $M_{j,i}$  is the force moment of muscle  $i$  in exercise  $j$ ,  $M_{i,\text{max}}$  is the maximum possible moment for muscle  $i$ ,  $\theta_{j,i}$  is the working joint angle,  $\theta_{i,\text{opt}}$  is the optimal angle for muscle  $i$  (the angle at which the muscle develops maximum force).

The function  $\cos(\theta_{j,i} - \theta_{i,\text{opt}})$  accounts for the fact that muscle force depends on muscle length, which in turn is determined by the joint angle. At the optimal angle ( $\cos$  coefficient = 1), the muscle develops maximum force; deviation from the optimum reduces force proportionally to  $\cos(\delta\theta)$ .

### Phase coefficient $K_{\text{phase}}$

$$K_{\text{phase},j,i}(\varphi) = C_{j,i}(\varphi) / C_{j,i,\text{max}} \quad (2.9)$$

where  $C_{j,i}(\varphi)$  is the relative contribution of muscle  $i$  at phase  $\varphi$  of exercise  $j$  (from anatomical tables),  $C_{j,i,\text{max}}$  is the maximum contribution across all phases of the exercise.

Practical significance: during a squat, the quadriceps dominate in the ascent phase (knee extension), while the glutes are more engaged in the descent

phase (hip extension).  $K_{\text{phase}}$  allows differentiating the muscle contribution at each phase of the exercise.

### Tempo coefficient $K_{\text{tempo}}$

$$K_{\text{tempo},j} = (t_{\text{ecc}}/t_{\text{tot}}) \times \alpha_{\text{temp}} + (t_{\text{iso}}/t_{\text{tot}}) \times \beta_{\text{temp}} + t_{\text{con}}/t_{\text{tot}} \quad (2.10)$$

where  $t_{\text{ecc}}$  is the eccentric phase duration (s),  $t_{\text{iso}}$  is the isometric phase duration (s),  $t_{\text{con}}$  is the concentric phase duration (s),  $t_{\text{tot}} = t_{\text{ecc}} + t_{\text{iso}} + t_{\text{con}}$  is the total repetition time,  $\alpha_{\text{temp}} \approx 1.3$  is the eccentric stress coefficient,  $\beta_{\text{temp}} \approx 1.5$  is the isometric stress coefficient.

The eccentric phase creates greater muscle stress (micro-damage), while the isometric phase creates greater metabolic stress (occlusion). The coefficient  $K_{\text{tempo}}$  accounts for these differences: powerlifting (3-0-X) gives  $K_{\text{tempo}} \approx 1.30$ , hypertrophy (2-1-1) gives  $K_{\text{tempo}} \approx 1.50$ .

### Amplitude coefficient $K_{\text{ampl}}$

$$K_{\text{ampl},j} = \text{ROM}_j / \text{ROM}_{\text{max}} \quad (2.11)$$

where  $\text{ROM}_j$  is the actual range of motion in exercise  $j$  (degrees),  $\text{ROM}_{\text{max}}$  is the maximum possible range for the given joints.

Exercises with a larger ROM engage more muscle fibers over a greater length, creating a more complete stimulus. Full squats ( $\text{ROM} \approx 140^\circ$ ) give  $K_{\text{ampl}} = 0.93$ , while bench press ( $\text{ROM} \approx 60^\circ$ ) gives only  $K_{\text{ampl}} = 0.67$ .

### 3. Mathematical structure

The state of the model is a system of nine ordinary differential equations.

| Variable | Meaning                                       | Scale                     |
|----------|-----------------------------------------------|---------------------------|
| mg       | endocrine gland mass (MG/MGmax)               | slow — updated once a day |
| hg       | hormone concentration in the gland (HG/HGmax) | fast — 1-second step      |
| hb       | hormone concentration in blood (HB/HBmax)     | fast — 1-second step      |
| hm       | hormone concentration in muscle (HM/HMmax)    | fast — 1-second step      |
| mf       | myofibril mass (MF/MFmax)                     | slow — updated once a day |
| mx       | mitochondria mass (MX/MXmax)                  | slow — updated once a day |
| hplus    | hydrogen ion concentration (H+)               | fast — 1-second step      |

#### 3.1. Three muscle contraction regimes

- Isometric (native): above 30% of MVC the vessels are compressed (occlusion) — hormone delivery to the muscle (hm) is limited, H<sup>+</sup> accumulates faster and is removed slower; at relaxation reactive hyperemia enhances metabolite washout and hormone delivery. Metabolic stress becomes an independent anabolic stimulus.
- Dynamic (concentric): classical model coefficients; fatigue inside a set reduces the effective intensity of subsequent reps.
- Eccentric: intensity may exceed 100% of MVC (load factor 1.30, cap about 180% of MVC); the higher micro-damage gives a stronger stress stimulus (multiplier 1.3).

### **3.2. Night rest**

During night sleep and further rest (16 hours in total) the fast variables approach equilibrium exponentially; the day totals are closed by a single update of the slow variables.

## 4. Model parameters

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### 4.1. Base coefficients of the model

| Coefficient         | Value  | Description                                         |
|---------------------|--------|-----------------------------------------------------|
| $k_1$               | 0.50   | Hormone synthesis in gland during exercise (1/h)    |
| $k_{1,\text{rest}}$ | 0.15   | Hormone synthesis at rest (1/h)                     |
| $k_2$               | 5.00   | Hormone secretion from gland to blood (1/h)         |
| $k_3$               | 0.12   | Hormone elimination from blood (liver, 1/h)         |
| $k_4$               | 3.00   | Hormone uptake by muscle from blood (dynamics, 1/h) |
| $k_6$               | 0.05   | Hormone elimination from muscle (1/h)               |
| $k_{\text{gs}}$     | 0.060  | Endocrine gland synthesis (1/day)                   |
| $k_{\text{gd}}$     | 0.040  | Endocrine gland degradation (1/day)                 |
| $k_{\text{gi}}$     | 4.00   | Inhibition of gland degradation by hormones         |
| $k_{\text{ms}}$     | 0.045  | Myofibril synthesis (1/day)                         |
| $k_{\text{md}}$     | 0.0020 | Myofibril degradation (1/day)                       |
| $k_{\text{mi}}$     | 3.00   | Stress stimulus multiplier for MF                   |
| $k_{\text{xs}}$     | 0.055  | Mitochondria synthesis (1/day)                      |
| $k_{\text{x0}}$     | 0.010  | Baseline mitochondria synthesis at rest (1/day)     |
| $k_{\text{xd}}$     | 0.020  | Mitochondria degradation (1/day)                    |
| $k_{\text{xh}}$     | 0.20   | Mitochondria damage by $\text{H}^+$                 |
| $k_{\text{h}}$      | 6.00   | $\text{H}^+$ accumulation rate (1/h)                |
| $k_{\text{hr}}$     | 8.00   | $\text{H}^+$ removal rate (1/h)                     |
| $n$                 | 2.0    | Hill coefficient (nonlinearity)                     |
| $I_{\text{at}}$     | 0.30   | Anaerobic threshold intensity                       |
| stress_threshold    | 0.50   | Intensity threshold for muscle stress               |

The isometric regime additionally modifies the coefficients (occlusion factors), the eccentric regime applies the above-MVC load factor. Exact values live in the engine module and are subject to per-user calibration.

## 4.2. Personal parameters

The initial state and coefficients are scaled by body weight, age group, gender, body type and training experience; personal MVC measurements refine the intensity normalization.

## 5. Calculation method

### 5.1. Algorithm of a simulation day

1. Plan activities are integrated with a 1-second step: exercise steps update the fast variables; integral doses of hormones,  $H^+$ , stress and aerobic stimulus are accumulated.
2. Intensity guard: the k-Energy day modifier scales the effective intensity of the sessions without raising it above 100% of MVC.
3. Daytime rest between the end of the session and night sleep is simulated with 1-minute steps.
4. Night sleep and further rest (16 hours in total) are closed analytically; the removal rate of  $H^+$  is multiplied by the k-Recovery of the day.
5. The slow variables are updated once: endocrine gland, myofibrils (scaled by k-Anabolic) and mitochondria (scaled by 0.3 of the ration deviation).

### 5.2. Simulation results

The output includes final masses (mf/mx/mg), daily trajectories with day modifier values, a per-exercise (per-muscle) component simulation, the peak of  $H^+$  and integral doses per day. The results feed the workout page, the Optimizer, the AI Coach and the accuracy reports.

## 6. Nutrition and the adaptation forecast

Since version with nutrition integration, the MIDA forecast accounts for the ration and nutrition regime alongside training load. The system uses nine Seluyanov ODEs unchanged; the ration enters through day modifiers: k-Anabolic (protein per kg, protein distribution, energy balance) scales myofibril growth, k-Energy (energy balance, glycogen estimate) adjusts the effective intensity of a day's sessions, k-Recovery (evening protein, energy sufficiency) accelerates H<sup>+</sup> removal during the 16-hour night block.

Two ration sources are available: recommended phase targets (default) or a user nutrition plan for the forecast horizon (1-365 days). A severe energy deficit does not increase the stimulus — the optimizer reduces volume (number of sets) while keeping intensity, and the AI Coach creates a ration correction when the fact deviates from phase targets.

### 6.1. Day modifiers

k-Anabolic is driven by protein per kg of body weight, protein distribution across meals (30–40 g per meal) and a non-negative energy balance; k-Energy — by the glycogen estimate (the carbohydrate share of the target); k-Recovery — by evening protein and energy sufficiency.

### 6.2. Ration sources

Phase targets (default): the forecast assumes the recommended ration of the phase — all day coefficients equal 1.0.

Custom plan: the user sets a per-day or per-week ration for the forecast horizon (1–365 days). Days below the safe minimum of 1200 kcal are replaced by phase targets; a plan shorter than the horizon cycles. The editor pre-fills the plan from phase targets (Create from phase targets) and validates the JSON on the fly.

### 6.3. Nutrition loop closure

Optimizer: with today's energy balance at  $-500$  kcal/day or lower, the volume of the optimized plans is reduced ( $\times 0.80$ , and  $\times 0.60$  at  $-1000$  kcal/day) by cutting the number of sets — the intensity is kept.

AI coach: when the fact deviates from the phase targets for three consecutive days (protein below 70% or calories below 85% of the target), a nutrition correction with the numbers is created.

## 6.4. Calibration

Verified records of MF simulations (with nutrition tracking on) give a per-user scale of k-Anabolic: the mean actual/forecast ratio is kept within 0.85–1.15 and stored in the nutrition profile.

## 7. Optimizer and AI Coach

The optimizer searches weekly training plans: candidate generation → surrogate filtering → exact MIDA evaluation (with the ration profile and periodization) → the objective per goal → top-5 plans. Modes: hard, loyal, maximum; horizons 30–365 days; per-user ODE calibration and personal MVC are applied.

The AI coach connects forecasts with daily practice: automatic adjustments by the health traffic light, plateau, overtraining and nutrition mismatch; escalation to a human coach; combo mode.

## 8. Verification and accuracy

Every forecast can be verified: the platform compares the predicted masses with real measurements (grip strength, BOLT index, body composition, HRV) and records the error. Verified records feed per-user calibration and the AI training datasets; accuracy trends are published on the accuracy page.

## 9. Model limitations

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- The model is a simplification: it does not replace medical consultation and is not an individual prescription.
- The nutrition impact is modeled with day modifiers and a conservative calibration; individual metabolic responses may vary.
- Forecast quality depends on the quality of the input: an honest diary, accurate weights and intensities.
- The k-Energy/k-Recovery ration factors are calibrated as verification statistics accumulate (v2).

## 10. Conclusion

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MIDA in Samson-fit combines the scientific school of Prof. V.N. Seluyanov with software verification: three contraction regimes, a personal forecast horizon from 1 to 365 days, the ration as a first-class input, and an automatic correction loop through the Optimizer and the AI Coach.

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## Appendix A. Summary table of time constants

| Variable | Process                      | Time constant          | $T_{1/2}$ (days) |
|----------|------------------------------|------------------------|------------------|
| $mg$     | Gland synthesis              | $1/k_{gs} = 16.7$ d.   | 11.6             |
| $mg$     | Gland degradation            | $1/k_{gd} = 25.0$ d.   | 17.3             |
| $mf$     | Myofibril synthesis          | $1/k_{ms} = 22.2$ d.   | 15.4             |
| $mf$     | MF degradation               | $1/k_{md} = 500$ d.    | 346              |
| $mx$     | Mitochondria synthesis       | $1/k_{xs} = 18.2$ d.   | 12.6             |
| $mx$     | MX degradation               | $1/k_{xd} = 50$ d.     | 34.7             |
| $hg$     | Hormone synthesis (exercise) | $1/k_1 = 2$ h          | 1.4              |
| $hg$     | Hormone synthesis (rest)     | $1/k_{1,rest} = 6.7$ h | 4.6              |
| $hb$     | Elimination from blood       | $1/k_3 = 8.3$ h        | 5.8              |
| $hm$     | Muscle uptake                | $1/k_4 = 0.33$ h       | 0.23             |
| $hm$     | Elimination from muscle      | $1/k_6 = 20$ h         | 14               |
| $H^+$    | Accumulation                 | $1/k_h = 0.17$ h       | 0.12             |
| $H^+$    | Removal (dynamics)           | $1/k_{hr} = 0.125$ h   | 0.087            |
| $H^+$    | Removal (occlusion)          | $1/k_{hr,iso} = 0.5$ h | 0.35             |

## Appendix B. Day algorithm pseudocode

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Simplified pseudocode of the current engine (apps/mida/engine.py):

```
for day in 1..num_days:
    nd = nutrition[(day - 1) % len(nutrition)]    # рационные коэффициенты дня
    for activity in day_plan:
        I_eff = clip(activity.intensity * day_factor * nd.k_energy, MVC_limit)
        step(state, I_eff, dt=1s)                # быстрые переменные (hg/hb/hm/H+)
        accumulate integrals (hb, H+, stress, aero)
    rest_steps(state, daytime_rest_hours, dt=1min)
    rest_decay(state, 16h, recovery_mult=nd.k_recovery) # ночь — аналитически
    slow_update(state, doses, k_anabolic=nd.k_anabolic) # mg, mf, mx раз в сутки
```

## Appendix C. Biomechanical coefficients for main exercises

This appendix provides an extended table of biomechanical coefficients for main strength exercises.  $K_{\text{biomech}}$  values are calculated by formula (2.8) based on anatomical data on force moments and optimal angles.  $K_{\text{ampl}}$  values are calculated by formula (2.11).  $K_{\text{tempo}}$  is calculated by formula (2.10) for the 'hypertrophy (2-1-1)' tempo unless otherwise specified.

**Table 4: Biomechanical coefficients for main exercises**

| Exercise       | Target muscle    | $K_{\text{biomech}}$ | $\theta_{\text{opt}} (^{\circ})$ | ROM ( $^{\circ}$ ) | $K_{\text{ampl}}$ |
|----------------|------------------|----------------------|----------------------------------|--------------------|-------------------|
| Barbell squats | Quadriceps       | 0.92                 | 90                               | 140                | 0.93              |
| Barbell squats | Glutes           | 0.85                 | 90                               | 140                | 0.93              |
| Bench press    | Pectoralis major | 0.88                 | 90                               | 60                 | 0.67              |
| Bench press    | Triceps          | 0.72                 | 90                               | 60                 | 0.67              |
| Deadlift       | Back extensors   | 0.90                 | 45                               | 90                 | 0.75              |
| Deadlift       | Glutes           | 0.78                 | 45                               | 90                 | 0.75              |
| Pull-ups       | Latissimus       | 0.90                 | 120                              | 120                | 0.80              |
| Push-ups       | Pectoralis major | 0.75                 | 90                               | 90                 | 0.60              |
| Lunges         | Quadriceps       | 0.80                 | 90                               | 100                | 0.67              |

**Table 5: Tempo coefficients**

| Mode                 | $t_{\text{ecc}}(\text{s})$ | $t_{\text{iso}}(\text{s})$ | $t_{\text{con}}(\text{s})$ | $K_{\text{tempo}}$ |
|----------------------|----------------------------|----------------------------|----------------------------|--------------------|
| Powerlifting (3-0-X) | 3                          | 0                          | X (fast)                   | 1.30               |
| Hypertrophy (2-1-1)  | 2                          | 1                          | 1                          | 1.50               |
| Speed (X-0-1)        | X (fast)                   | 0                          | 1                          | 0.70               |
| Isometric (0-5-0)    | 0                          | 5                          | 0                          | 1.50               |

**Table 6: Phase coefficients for squat**

| Exercise phase      | Angle (°) | $K_{\text{phase}}$ | Time fraction |
|---------------------|-----------|--------------------|---------------|
| Descent (eccentric) | 0-50      | 0.60               | 35%           |
| Bottom (squat)      | 50-90     | 0.85               | 10%           |
| Ascent (concentric) | 90-100    | 1.00               | 45%           |
| Top (lockout)       | 100-140   | 0.75               | 10%           |

**Table 8: Extended table of biomechanical coefficients**

| Exercise        | Target muscle    | $K_{\text{biomech}}$ | $\theta_{\text{opt}} (^{\circ})$ | ROM ( $^{\circ}$ ) | $K_{\text{ampl}}$ | $K_{\text{tempo}}$ |
|-----------------|------------------|----------------------|----------------------------------|--------------------|-------------------|--------------------|
| Barbell squats  | Quadriceps       | 0.92                 | 90                               | 140                | 0.93              | 1.30               |
| Barbell squats  | Glutes           | 0.85                 | 90                               | 140                | 0.93              | 1.30               |
| Barbell squats  | Back extensors   | 0.70                 | 45                               | 140                | 0.93              | 1.30               |
| Bench press     | Pectoralis major | 0.88                 | 90                               | 60                 | 0.67              | 1.30               |
| Bench press     | Triceps          | 0.72                 | 90                               | 60                 | 0.67              | 1.30               |
| Bench press     | Deltoid (ant.)   | 0.60                 | 90                               | 60                 | 0.67              | 1.30               |
| Deadlift        | Back extensors   | 0.90                 | 45                               | 90                 | 0.75              | 1.30               |
| Deadlift        | Glutes           | 0.78                 | 45                               | 90                 | 0.75              | 1.30               |
| Deadlift        | Quadriceps       | 0.65                 | 90                               | 90                 | 0.75              | 1.30               |
| Pull-ups        | Latissimus       | 0.90                 | 120                              | 120                | 0.80              | 1.50               |
| Pull-ups        | Biceps           | 0.55                 | 90                               | 120                | 0.80              | 1.50               |
| Push-ups        | Pectoralis major | 0.75                 | 90                               | 90                 | 0.60              | 1.50               |
| Push-ups        | Triceps          | 0.65                 | 90                               | 90                 | 0.60              | 1.50               |
| Lunges          | Quadriceps       | 0.80                 | 90                               | 100                | 0.67              | 1.30               |
| Lunges          | Glutes           | 0.75                 | 90                               | 100                | 0.67              | 1.30               |
| Leg press       | Quadriceps       | 0.80                 | 90                               | 80                 | 0.53              | 1.30               |
| Leg press       | Glutes           | 0.65                 | 90                               | 80                 | 0.53              | 1.30               |
| Dumbbell raises | Deltoid (mid.)   | 0.70                 | 90                               | 90                 | 0.60              | 1.50               |
| Bicep curls     | Biceps           | 0.85                 | 90                               | 140                | 0.93              | 1.50               |
| Leg extensions  | Quadriceps       | 0.88                 | 90                               | 90                 | 0.60              | 1.30               |
|                 | Latissimus       | 0.82                 | 120                              | 80                 | 0.53              | 1.30               |

| Exercise      | Target muscle  | $K_{\text{biomech}}$ | $\theta_{\text{opt}} (^{\circ})$ | ROM ( $^{\circ}$ ) | $K_{\text{ampl}}$ | $K_{\text{tempo}}$ |
|---------------|----------------|----------------------|----------------------------------|--------------------|-------------------|--------------------|
| Bent-over row |                |                      |                                  |                    |                   |                    |
| Bent-over row | Back extensors | 0.78                 | 45                               | 80                 | 0.53              | 1.30               |

**Table 9: Tempo coefficients for various modes**

Calculation parameters:  $\alpha_{\text{tempo}} = 1.3$  (eccentric stress coefficient),  $\beta_{\text{tempo}} = 1.5$  (isometric stress coefficient).

| Mode                 | $t_{\text{ecc}}(\text{s})$ | $t_{\text{iso}}(\text{s})$ | $t_{\text{con}}(\text{s})$ | $t_{\text{tot}}(\text{s})$ | $K_{\text{tempo}}$ |
|----------------------|----------------------------|----------------------------|----------------------------|----------------------------|--------------------|
| Powerlifting (3-0-X) | 3.0                        | 0.0                        | 0.5                        | 3.5                        | 1.30               |
| Hypertrophy (2-1-1)  | 2.0                        | 1.0                        | 1.0                        | 4.0                        | 1.50               |
| Speed (X-0-1)        | 0.5                        | 0.0                        | 1.0                        | 1.5                        | 0.70               |
| Isometric (0-5-0)    | 0.0                        | 5.0                        | 0.0                        | 5.0                        | 1.50               |
| Super-slow (4-2-4)   | 4.0                        | 2.0                        | 4.0                        | 10.0                       | 1.52               |
| Explosive (X-0-X)    | 0.5                        | 0.0                        | 0.5                        | 1.0                        | 0.65               |
| Control (2-0-2)      | 2.0                        | 0.0                        | 2.0                        | 4.0                        | 1.15               |

#### Notes on tables

- $K_{\text{biomech}}$  is calculated by formula (2.8) using anatomical data on muscle force moments at various joint angles.
- $K_{\text{ampl}}$  is calculated by formula (2.11). Maximum ROM values are taken from anatomical reference books: knee — 150°, shoulder — 180°, hip — 150°, elbow — 150°.
- $K_{\text{tempo}}$  is given for the standard 'hypertrophy (2-1-1)' tempo unless otherwise specified. To calculate  $K_{\text{tempo}}$  for other tempos, use formula (2.10).
- $K_{\text{biomech}}$  values for auxiliary muscles (antagonists, stabilizers) are typically lower than for target muscles and can be refined using EMG data.
- 'X' means explosive (maximum speed) phase execution,  $t_{\text{con}} \approx 0.5$  s for practical calculations.