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Optimization and Personalization of Fitness Routines Using Mathematical Models

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Optimization and Personalization of Fitness Routines Using Mathematical Models

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Abstract

This project aims to develop a mathematical model for generating personalized workout plans tailored to individual fitness goals, preferences, and constraints. By leveraging optimization techniques such as linear programming and genetic algorithms, the model will address key questions, including how to maximize efficiency and consistency in workout plans and which methodologies are best suited for specific fitness objectives. The model involves data collection on user inputs and exercise attributes, defining objective functions for different goals, and integrating constraints like session duration. The implementation will utilize the Python library PuLP to prototype the model, alongside a user-friendly interface for input and output visualization. Validation will be conducted through hypothetical scenarios and feedback from gym-goers, with statistical analysis comparing the model's results to standard fitness plans.

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1. Introduction

Designing a workout plan that aligns with an individual's goals, constraints, and physiological capabilities continues to be a challenge in fitness planning. Effective routines must account for a variety of personal factors: training experience, time availability, recovery needs, preferred training styles, and access to equipment. However, most traditional workout plans are based on heuristics, intuition, or rigid templates. While these methods may be effective in specific contexts, they tend to lack flexibility and scalability when applied across diverse populations. Generic fitness apps, though accessible, often suffer from the same limitations.

These shortcomings are further compounded by the complex landscape of the fitness industry. With a growing emphasis on specialization, social media-driven trends, and new modalities of training, beginners and experienced lifters alike are often overwhelmed with conflicting advice and clouded pathways to progress. The result is a gap between the need for accessible, effective guidance and the tools available to meet that need. Individuals may find themselves using plans that are inefficient, mismatched to their goals, or unsustainable in the long term.

Mathematical optimization provides a promising alternative. By approaching workout design as a structured decision-making problem, it becomes possible to develop routines that are dependable. This paper explores the application of Integer Linear Programming (ILP), a mathematical technique used to solve optimization problems with discrete variables, to the generation of individualized workout plans. The proposed model is capable of systematically selecting exercises that maximize training effectiveness while satisfying a wide range of user-specific constraints.

1.1 Description of the Problem

Most existing fitness plans lack a systematic, data-driven method for generating routines tailored to an individual's constraints and goals. While some commercial tools allow users to input general preferences, they often fail to adjust meaningfully to critical variables such as training frequency, recovery needs, equipment access, or the balance between compound and isolation movements (Kraemer & Fleck, 2007). As a result, users may follow suboptimal plans that do not reflect current best practices in exercise science or their own physical realities.

Meanwhile, optimization algorithms have been used to address similar problems in resource allocation, scheduling, and planning (Boyd & Vandenberghe, 2004). They offer a way to incorporate complex constraints and prioritize multiple objectives within a consistent mathematical framework. This project leverages that approach, using ILP to build a model that can automatically design workout plans aligned with individual preferences, constraints, and fitness principles.

1.2 Organization of the Paper

The remainder of this paper is organized as follows:

- Section 2 reviews prior work in the application of optimization methods to fitness planning and related areas.
- Section 3 outlines the data collection methodology, including how exercises were selected, categorized, and assigned quantitative effectiveness scores.
- Section 4 introduces the mathematical model used in this project, detailing the decision variables, objective function, constraints, and user-defined inputs.
- Section 5 presents the results of applying the model to a range of user profiles and compares the ILP-generated routines to traditional fitness templates.
- Section 6 concludes the paper with a discussion of key findings, limitations, practical implications, and directions for future research.

2. Literature Review

2.1 Fitness Principles

Effective workouts are based on a series of well-established principles of exercise science: progressive overload, specificity, variation, and recovery. Each of these helps determine muscle selection, distribution, and intensity of exercises in any given training plan.

2.1.1 Progressive Overload

Progressive overload is one of the most fundamental principles of exercise science; it refers to the increase the tension placed on the body to stimulate adaptations in strength, hypertrophy, or endurance (Baechle & Earle, 2008). Without appropriate progression, individuals may experience plateaus or even regressions in performance. The most effective plan's structure workouts to incrementally challenge the individual, either through increasing resistance, reps, or complexity.

2.1.2 Training Specificity

Muscle groups targeted, velocity, and force of movement, as well as required energy, are all proponents of training specificity (Kraemer & Ratamess, 2004). For example, strength development in the lower body is best supported by squats and deadlifts, while endurance training would be better suited with longer-duration exercises like swimming. Personalized programming should align the chosen exercises with the individual's goals to be most effective.

2.1.3 Volume

Volume is vital in the implementation of workout plans. This will vary depending on the fitness level of the individual. For a beginner, it is possible to build muscle in 1 to 5 sets per muscle per week (Shoenfeld et al., 2016). But, for more intermediate or advanced gym goers, more exercises will be needed to stimulate growth. Volume must be sufficient to stimulate growth without surpassing an individual's recovery capacity. Excessive volume can lead to injury if not managed appropriately.

2.1.4 Exercise Selection

There are two types of movements that exercises are grouped into: compound and isolation. Compound lifts activate multiple muscle groups and joints. Isolation movements allow for targeted muscular development and recovery and are overall less taxing on the body. According to Suchomel et al. (2016), compound lifts should form the foundation of programs but must be regulated to prevent fatigue and nervous system strain.

2.1.5 Recovery

Recovery is just as important for muscle as time under tension. The body needs time to adjust to stress, and poor recovery management diminishes results while increasing the risk of injury and burnout. Periodization strategies are often used to balance stress and recovery over time (Buford et al., 2007)

2.2 Heuristic Methods

Many plans in practice are built using heuristic or rule-of-thumb approaches. While generally proven to be effective through personal experience, anecdotal evidence, or generalized templates, these methods lack personalization, scalability, and logical consistency. They may work for certain individuals; for others, though, the plans can become rigid and generic or fail to align with an individual's goals.

Popular workout templates include the Push/Pull/Legs (PPL) split and the "bro split." The PPL routine divides workouts into three categories: pushing movements like bench press and shoulder press, pulling movements like lateral pulldowns and pull-ups, and lower-body exercises like squats and deadlifts. This plan can be used in 3- or 6-day cycles and is valued for simplicity, modularity, and balanced muscle group distribution (Shoenfeld et al., 2016). By contrast, the bro split assigns each major muscle group to its own day: chest, back, shoulders, legs, and arms. This approach is popular in bodybuilding circles, but they can suffer from low training frequency for each muscle group and is suboptimal for hypertrophy and strength development (Grgic et al., 2018).

However, this project does not aim to replace established methods. These templates offer a useful starting point for routine design. But they are limited in flexibility. They assume a fixed structure and do not adapt dynamically to factors like equipment availability, recovery needs, or time constraints. Most templates also lack the ability to regulate cumulative stress, avoid overuse, and prioritized movements based on experience level. Users often need to manually modify plans to maintain balance and progression. So, workout outlines were developed using the previously defined fitness and workout plan principles. Appendix B has a comprehensive list of exercise plans used in the model. Figure 1 represents an example of one of these plans:

```
three_day_ppl = {
    "name": "3-Day PPL",
    "goal": "gain muscle",
    "level": "Beginner",
    "day_count": 3,
    "days": {
        "Day 1": {
            "focus": ["chest", "shoulders", "triceps"],
            "max_compounds": 2,
            "max_exercises": 5
        },
        "Day 2": {
            "focus": ["back", "biceps", "core"],
            "max_compounds": 2,
            "max_exercises": 5
        },
        "Day 3": {
            "focus": ["quads", "glutes", "hamstrings", "calves"],
            "max_compounds": 2,
            "max_exercises": 5
        }
    }
}
```

Figure 1: 3-Day Push Pull Legs split skeleton plan

2.3 Integer-Linear Programming in Decision Making

ILP is a form of mathematical optimization with the goal to maximize or minimize an objective function, subject to a set of linear constraints, with the added condition that decision variables must be integers. ILP has been widely adopted in operational research domains where discrete choices must be made under limited resources, such as workforce scheduling, manufacturing, and transportation planning (Winston & Goldberg, 2004).

In an ILP model, each decision variable represents a specific choice. The model attempts to select the best combination of choices that maximize a defined objective function while satisfying the constraints. For workout planning, this can be effective when selecting useful exercises that fit within muscle coverage, time, equipment, and fatigue.

ILP offers two major advantages over heuristic methods: guaranteed feasibility and optimality. In contrast to rule-based systems that rely on fixed logic, ILP allows for complex interaction among constraints and goals without sacrificing scalability (Bertsimas & Tsitsiklis, 1997).

3. Data Collection

3.1 Integer-Linear Programming in Decision Making

The foundation of this model is in its curated database of exercises. Data was gathered from a combination of online strength training databases (e.g., ExRx.net) and structured programing guides published by exercise science professionals. Exercises were selected to represent a variety of equipment types, movement patterns, and targeted muscle groups. The selection prioritizes compound movements that engage multiple joints and muscles, but the compound exercises are limited based on plan structure and user fitness level.

Each exercise entry was annotated with metadata to support the optimization logic:

- Primary Muscle group(s)
- Exercise Type
- Equipment Requirements
- Estimated Effectiveness Score

Further information regarding the exercise database can be found in Appendix A.

Effectiveness scores were assigned using expert recommendations and scientific literature that prioritize multi-joint movements for general strength and hypertrophy development (Bird, Tarpenning, & Marino, 2005). For example, `flat_barbell_bench_press` received a higher effectiveness than a `barbell_floor_press` due to its broader muscle activation and greater systematic demand. The compiled exercise database is stored in a structured list of dictionaries.

3.2 User Input Framework

The model prompts users to set parameters for the model through a brief set of customizable inputs. These are designed to mirror the choices a personal trainer might consider during an intake session:

- Day Count: total number of days from 2-6
- Integrated workout frameworks range from 2- to 6-day routines
- Current Fitness Level: experience level of user (beginner/intermediate/advanced)
- Fitness Goal: primary goal of the user (maintenance/gain muscle/fat loss)
- Equipment: user can sort equipment that is available or preferred
- Cardio Option: user may add cardio exercises to workout

These inputs are translated into constraints for the ILP model. For example, equipment availability limits feasible exercises, while the day count determines the number of sessions that must be filled. The flexibility of this framework allows the model to accommodate a broader spectrum of fitness programming. A full explanation regarding user input will be provided in section 4.

3.3 Standardization

The exercise database was standardized to ensure the model is consistent and efficient. Each exercise was assigned a unique identifier, and muscle groups were mapped about the muscles that the exercise focused on (e.g., “chest,” “quads,”).

The pipeline was as follows:

1. Exercise Filtering: The model filters exercises based on the user’s equipment availability. For example, if a user did not have access to or otherwise wanted to exclude a barbell in their routine, all barbell exercises would be excluded from the pool of potential exercises.
2. Effectiveness Normalization: Effectiveness scores were scaled to a range of 1 to 10, with higher values indicating greater alignment with fitness principles. Compound movements would score higher on average, as they targeted the widest range of muscles and typically stimulate the most growth.
3. Cardio Integration: For users selecting cardio options, exercises tagged as high-intensity interval training (`hiit`), steady state exercises (`steady_state`), or interval (`interval`) were included in a separate pool of exercises. This pool is also accessed when considering Fat Loss programs.

These preprocessing steps ensure that the optimization model operates on relevant data that was tailored to each individual user.

4. Mathematical Model

The design of an effective workout plan is treated as a constrained optimization problem. ILP is used to select a set of exercises that maximize a defined effectiveness score while satisfying personalized constraints. The model incorporates principles of exercise science like muscle coverage and equipment accessibility into a structed mathematical framework. This allows the model to generate a plan that is not only optimized but also practically useful for individuals with diverse backgrounds and constraints.

This model operates on several core components: ranges to define sets over which the model iterates, parameters to encode exercise and user-specific information, decision variable to determine exercise selection, an objective function to guide the optimization, and constraints to ensure the solution is viable and purposeful.

4.1 Ranges

This model operates on defined sets. These turn the input data into usable mathematical groups. The ranges are designed to allow the model to iterate over exercises, days, and muscle groups systematically. This is essential for both constraint enforcement and plan structuring. The constraints are as follows:

- Let E be the set of all exercises, indexed by $i \in \{1,2,\dots,N\}$, where N is the total number of exercises in the database. For implementation, refer to Appendix A
- Let D be the set of workout days, indexed by $i \in \{1,2,\dots,\texttt{day\_count}\}$, where `day_count` is a user-defined constraint
- Let M be the set of target muscle groups (e.g., chest, quads) indexed by m

4.2 Parameters

Each element in the model is assigned to metadata to guide decision-making. These parameters encode static information as well as user-specific preferences like equipment availability. Each keeps the model's logic sensitive to the structure of the workout as well as to user-specific limitations and goals.

- Effectiveness Score: $e_i \in [1,10]$ for exercise i
- Exercise Type: $\text{type}_i \in \{\text{compound}, \text{isolation}\}$
- Equipment: binary flag eq_i indicating if exercise i requires equipment available or preferred by the user
- Muscle Targeting: $\text{target}_{i,m} = 1$ if exercise i targets muscle m, else 0
- Program Rules: For each day j:
    - $\text{focus}_j \subseteq M$: Target muscle groups
    - $\texttt{max\_compounds}_j$: Maximum number of compound exercises allowed per day
    - $\texttt{max\_exercises}_j$: Total number of exercises allowed per day

4.3 Decision Variables

The primary decision variable in the model is a binary indicator that determines the specific allocation of exercises across days. These variables allow the model to assemble the plans that adhere to the user-specified constraints and program rules.

$$x_{i,j} = \begin{cases} 1, \text{ if exercise } i \text{ is assigned to day } j \\ 0, \text{ otherwise} \end{cases}$$

$y_j \in \mathbb{Z}^+$: number of compound lifts assigned to day j.

4.4 Objective Function

The objective of the model is to maximize total training effectiveness across each session. This is represented by the sum of effectiveness scores s_i for all selected exercises over all days. The model was developed to maximize:

$$\text{maximize } z = \sum_{i \in E} \sum_{j \in D} s_i * x_{i,j}.$$

This objective function governs, given the chosen exercises across each session, the final workout plan; it prioritizes selections that contribute most significantly to the user's fitness goals.

4.5 Constraints

Constraints are implemented to generate a safe, balanced, and practical plan:

4.5.1 Muscle Coverage

Each target muscle $m \in \text{focus}_j$ must be trained at least once per day. This prevents the generation of unbalanced plans that may ignore muscle groups:

$$\sum_{i \in E} \sum_{j \in D} t_{im} * x_{i,j} \geq 1 \quad \forall j \in D, \forall m \in \text{focus}_j.$$

4.5.2 Compound Lift Limit

Respect daily compound exercise caps. Compound lifts are more taxing and require longer recovery. So, this constraint is designed to ensure sustainability:

$$\sum_{i \in E} x_{i,j} * \mathrm{I}(\text{type}_i = \text{compound}) \leq \texttt{max\_compounds}_j.$$

4.5.3 Exercise Limit

Each day must adhere to a maximum number of total exercises permitted per day to maintain session durations:

$$\sum_{i \in E} x_{i,j} \leq \texttt{max\_exercises}_j \quad \forall j \in D.$$

4.5.4 Equipment Availability

Exercises requiring unavailable equipment are excluded, so the model can respect real-world constraints like home gym users:

$$x_{i,j} = 0 \quad \forall i \text{ where } \mathrm{eq}_i \notin \texttt{user\_equpiment}.$$

4.5.5 Exercise Uniqueness

Each exercise can only appear at most once across each day to avoid overuse:

$$\sum_{i \in D} x_{i,j} \leq 1 \quad \forall i \in E.$$

5. Implementation

To translate the model into code, a Python-based generator was developing using data structures and control logic made to mirror the concepts proposed in the previous section. The application is composed of several modules that collect user preferences, select a compatible workout plan, and generate optimized routines. The code uses Python library `PuLP` for linear programming, and it uses structured dictionaries and lists to represent plans, exercises, and constraints.

5.1 Exercise Metadata

The first section of the code is the exercise database. Exercises are stored in a structured format; that is, each is its own dictionary containing its name, type, primary muscle groups, required equipment, and assigned effectiveness score. This format simplifies the code and prevents the need for outside data sets. The model can use the dictionary to assign values to decision variables and evaluate constraints. The comprehensive exercise set can be found in Appendix A.

5.2 Workout Plan Templates

Several predefined routine structures are stored as Python dictionaries. Each plan specifies the following:

- `day_count`: number of workout days
- `focus`: muscle groups to be trained each day
- `max_compounds`: maximum number of compound exercises
- `max_exercises`: maximum number of exercises
- `cardio`: optional cardio addition to plans

These parameters serve as the program rules as described in Section 4.2. They allow the model to constrain each day based on the goals of the routine. Each plan is also tagged with metadata about intended goals and fitness levels, which help with plan recommendation.

5.3 User Input Framework

A core function in the code prompts users to obtain certain constraints:

- How many days they can work out per week
- Their fitness level
- Their primary goal
- Whether they want to include cardio exercises
- What equipment do they have available

This input is collected and returned as a dictionary. The resulting structure mirrors the variables described in the mathematical model. Each provide bounds and constraints that the model can enforce when selecting feasible exercises and plan structures.

5.4 Program Recommendation Logic

Once the user inputs are collected, a scoring function filters through the available plans and selects the most appropriate. Goal alignment is the most heavily weighted. It will always match what the user has proposed. Next is level appropriateness. Then, the model makes sure the day count is less than or equal to the user's maximum day count.

Plans are ranked by compatibility score; the highest scoring plan is selected for further processing. This decision mirrors the ILP's role in finding a feasible, optimal solution. In this case, the plan selection is done through a heuristic scoring method before the formal ILP phase begins.

5.5 Optimization Model Execution

After plans are selected, the template is passed into an ILP model defined by the `PuLP` library. Each exercise is filtered based on user equipment. Then, decision variables are created for each potential exercise-day assignment. Constraints from Section 4.5 are enforced in code using `PuLP` objects.

The objective function is implemented as the summation of effectiveness $* \; x_{i,j}$ variables. The solver then finds the optimal set of exercises that meet the plan structure while maximizing effectiveness.

5.6 Output Formatting

Finally, the solution is parsed to create a readable workout schedule. Exercises are grouped by day, and the results are returned as a weekly plan. The output includes both resistance training and optional cardio selections, depending on the user's goal and equipment availability.

6. Results

6.1 Output Analysis

6.1.1 Test Case 1

The first test case for the model was a basic plan. This is the simplest version of the plan the model can produce. The constraints were minimal; day count was set at 2, fitness level set for beginners, goal set to maintenance, cardio not preferred, and all equipment permitted.

The output generated was a 2-Day Full Body plan, which aligns perfectly with the user's preferences. The plan distributes exercises across two days, focusing on major muscle groups to achieve fitness goals in a timely manner:

```
Workout Program Selector
```

2-Day Full Body Plan (Maintain)

Day 1: ['chest', 'back', 'legs']

Strength Exercises (Compounds):

- `barbell_deadlift` (Eff: 10, Equipment: barbell)
- `flat_barbell_bench_press` (Eff: 9, Equipment: barbell)
- `pullups` (Eff: 10, Equipment: bodyweight)

Strength Exercises (Isolations):

- `cable_crossover` (Eff: 9, Equipment: cable)

Total exercises: 4

Day 2: ['shoulders', 'arms', 'hamstrings']

Strength Exercises (Compounds):

- `barbell_overhead_press` (Eff: 9, Equipment: barbell)
- `barbell_romanian_deadlift` (Eff: 9, Equipment: barbell)

Strength Exercises (Isolations):

- `cable_lateral_raise` (Eff: 9, Equipment: cable)
- `cable_rear_delt_fly` (Eff: 9, Equipment: cable)

Total exercises: 4

Figure 2: 2-Day Maintenance plan generated by model

The plan adheres to all the proposed constraints; it prioritizes effectiveness since the constraint of equipment is absent. The workout plan is also manageable for a beginner. Similarly, there were no cardio exercises included in this plan, as defined by the user. This output was straightforward and predictable, given the simplicity of the inputs. The model was able to prioritize high-effectiveness compound lifts and ensure balanced muscle group coverage.

6.1.2 Test Case 2

The second case was to evaluate the limits of the model more. To do this, the constraints were harsher. This plan was to test for more advanced users looking to develop a flexible plan that suits their goals and limited equipment; the day count was set to 5, fitness level set to advanced, goal set to gain muscle, cardio preferred, and the following equipment allowed: barbell, dumbbell, bodyweight,

The model recommended a 4-Day Bodybuilding Split, which is more complex due to stricter constraints. The model prioritized the user's goals and fitness level over the day count. The day count acts as a ceiling; the model selects plans within the user's maximum days. That is, the model will choose plans under the maximum days set by the user. So, like this case, the model can find plans that fit the user's preferences even if it is under their maximum days available to dedicate to the plan. The model also included cardio exercises with focuses on interval and high-intensity interval training to avoid conflicting with hypertrophy principles:

Workout Program Selector

4-Day Advanced Bodybuilding Plan (Gain Muscle)

Upper A (Push Focus): ['chest', 'shoulders', 'triceps']

Strength Exercises (Compounds):

- `flat_barbell_bench_press` (Eff: 9, Equipment: barbell)
- `barbell_overhead_press` (Eff: 9, Equipment: barbell)
- `barbell_close_grip_bench` (Eff: 9, Equipment: barbell)

Strength Exercises (Isolations):

- `barbell_skullcrusher` (Eff: 9, Equipment: barbell)
- `dumbbell_overhead_triceps` (Eff: 9, Equipment: dumbbell)

Cardio:

- `trail_running` (Interval, Eff: 10)

Total exercises: 6

Lower A (Quad Dominant): ['quads', 'glutes', 'core']

Strength Exercises (Compounds):

- `barbell_squat` (Eff: 10, Equipment: barbell)
- `pistol_squat` (Eff: 9, Equipment: bodyweight)
- `barbell_lunge` (Eff: 8, Equipment: barbell)

Strength Exercises (Isolations):

- `hanging_leg_raise` (Eff: 9, Equipment: bodyweight)
- `dumbbell_step_up` (Eff: 8, Equipment: dumbbell)

Cardio:

- `hill_running` (Interval, Eff: 10)

Total exercises: 6

Upper B (Pull Focus): ['back', 'biceps', 'rear delts']

Strength Exercises (Compounds):

- `barbell_deadlift` (Eff: 10, Equipment: barbell)
- `chinup` (Eff: 9, Equipment: bodyweight)
- `pullups` (Eff: 10, Equipment: bodyweight)

Strength Exercises (Isolations):

- `barbell_preacher_curl` (Eff: 9, Equipment: barbell)
- `concentration_curl` (Eff: 9, Equipment: dumbbell)

Cardio:

- `sprint_intervals` (Hiit, Eff: 10)

Total exercises: 6

Lower B (Hamstring Dominant): ['hamstrings', 'glutes', 'calves', 'core']

Strength Exercises (Compounds):

- `dumbbell_deadlift` (Eff: 8, Equipment: dumbbell)
- `barbell_step_up` (Eff: 8, Equipment: barbell)
- `dumbbell_squat` (Eff: 8, Equipment: dumbbell)

Strength Exercises (Isolations):

- `ab_wheel_rollout` (Eff: 9, Equipment: bodyweight)
- `barbell_romanian_deadlift` (Eff: 9, Equipment: barbell)

Cardio:

- `burpees` (Hiit, Eff: 10)

Total exercises: 6

Figure 3: 4-Day Bodybuilding plan generated by model

7. Conclusion

7.1 Key Findings

This project demonstrates the effectiveness of ILP as a tool for creating an optimal workout plan. By formalizing the workout design process into a structured mathematical model, the system can generate routines that balance muscle targeting, exercise effectiveness, and individual user constraints such as equipment availability and session length. In doing so, it can complete what traditional heuristic or template-based programs and instead provide a framework that adapts to user-specific needs.

One of the most impactful outcomes is the ability to deliver personalization. Whether the user is a beginner or advanced trainee, or the individual has no equipment limitations or just a few dumbbells and a treadmill, the ILP framework can construct routines that fit their own goals and physical realities. The model accounts for training volume, fatigue, and recovery by integrating practical exercise limits and emphasizing compound movements without overloading the user. This enables the program to make sustainable plans that help users stick to the gym.

Equally important is the ease of use. The model was developed with accessibility in mind, aiming to help newcomers transition into fitness without needing the prior expertise that traditional program design requires. By guiding users through simple input prompts and returning optimized results almost instantly, the system lowers the barrier to entry and makes high-quality fitness guidance approachable.

The model also exhibits scalability. It is capable of handling 2- to 6-day workout splits and is robust enough to serve users with varying levels of experience, goals, and equipment access. This flexibility means the model is not just a one-time solution but something that can evolve alongside a user’s fitness journey.

But this model has limitations. One of the primary constraints lies in the use of static effectiveness score. While these scores are grounded in exercise science, they may not reflect individual biomechanics or movement preferences. Similarly, the current exercise database may omit specialized exercises that some users might benefit from. This potentially limits the breadth of the model.

Recovery is modeled through limitations on compound and total exercise volume as well as the fitness level of the plan. But more nuanced factors like sleep, stress, or injury history are outside of the systems capabilities. The model is best used as a guided starting point in these cases rather than something to live by. Furthermore, the quality of the output is inherently dependent on the accuracy of user input. Misreporting training goals or equipment access can lead to mismatches.

Despite these challenges, the model serves as a “proof of concept” for how mathematical optimization can be used to bridge the gap between data-driven planning and practical fitness programming.

7.2 Future Work

The current system can be expanded and improved in several obvious ways. The incorporation of dynamic data from wearable technology is one interesting avenue. The model could modify plan recommendations daily and more accurately represent the idea of progressive overload over time by integrating real-time feedback, such as heart rate, sleep quality, or recovery scores.

Learning from user feedback is another possible improvement. The model could be further tailored to individual preferences and tolerances by incorporating a recommendation layer that modifies future in response to user satisfaction or completion data.

Finally, a commercial grade interface would be a worthwhile advancement. Mobile or web-based applications powered by an ILP backend could allow users to input their constraints, view their plans, track progress, and receive updates within an intuitive environment. That platform could serve not only individual users but also gyms, trainers, and educational settings that want to provide intelligent, scalable fitness support.

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Appendix A: Exercise Database

```
# CHEST EXERCISES
# Barbell
{"name": "flat_barbell_bench_press", "type": "compound", "muscles": ["chest"], "equipment": "barbell", "effectiveness": 9},
{"name": "incline_barbell_bench_press", "type": "compound", "muscles": ["chest"], "equipment": "barbell", "effectiveness": 8},
{"name": "decline_barbell_bench_press", "type": "compound", "muscles": ["chest"], "equipment": "barbell", "effectiveness": 8},
{"name": "barbell_floor_press", "type": "compound", "muscles": ["chest"], "equipment": "barbell", "effectiveness": 7},
{"name": "barbell_pullover", "type": "isolation", "muscles": ["chest"], "equipment": "barbell", "effectiveness": 6},
{"name": "barbell_guillotine_press", "type": "compound", "muscles": ["chest"], "equipment": "barbell", "effectiveness": 7},
# Dumbbell
{"name": "flat_dumbbell_press", "type": "compound", "muscles": ["chest"], "equipment": "dumbbell", "effectiveness": 9},
{"name": "incline_dumbbell_press", "type": "compound", "muscles": ["chest"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "decline_dumbbell_press", "type": "compound", "muscles": ["chest"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "dumbbell_fly", "type": "isolation", "muscles": ["chest"], "equipment": "dumbbell", "effectiveness": 7},
{"name": "dumbbell_pullover", "type": "isolation", "muscles": ["chest"], "equipment": "dumbbell", "effectiveness": 7},
{"name": "dumbbell_squeeze_press", "type": "compound", "muscles": ["chest"], "equipment": "dumbbell", "effectiveness": 7},
# Machine
{"name": "flat_machine_press", "type": "compound", "muscles": ["chest"], "equipment": "machine", "effectiveness": 7},
{"name": "incline_machine_press", "type": "compound", "muscles": ["chest"], "equipment": "machine", "effectiveness": 7},
{"name": "pec_deck_fly", "type": "isolation", "muscles": ["chest"], "equipment": "machine", "effectiveness": 8},
{"name": "machine_chest_press", "type": "compound", "muscles": ["chest"], "equipment": "machine", "effectiveness": 7},
{"name": "machine_incline_press", "type": "compound", "muscles": ["chest"], "equipment": "machine", "effectiveness": 7},
{"name": "machine_chest_fly", "type": "isolation", "muscles": ["chest"], "equipment": "machine", "effectiveness": 7},
# Cable
{"name": "cable_crossover", "type": "isolation", "muscles": ["chest"], "equipment": "cable", "effectiveness": 9},
{"name": "cable_flies", "type": "isolation", "muscles": ["chest"], "equipment": "cable", "effectiveness": 9},
{"name": "high_cable_crossover", "type": "isolation", "muscles": ["chest"], "equipment": "cable", "effectiveness": 8},
{"name": "low_cable_crossover", "type": "isolation", "muscles": ["chest"], "equipment": "cable", "effectiveness": 8},
{"name": "cable_chest_press", "type": "compound", "muscles": ["chest"], "equipment": "cable", "effectiveness": 7},
{"name": "single_arm_cable_press", "type": "compound", "muscles": ["chest"], "equipment": "cable", "effectiveness": 7},
# Bodyweight
{"name": "pushups", "type": "compound", "muscles": ["chest"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "wide_pushups", "type": "compound", "muscles": ["chest"], "equipment": "bodyweight", "effectiveness": 7},
{"name": "diamond_pushups", "type": "compound", "muscles": ["chest"], "equipment": "bodyweight", "effectiveness": 7},
{"name": "decline_pushups", "type": "compound", "muscles": ["chest"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "incline_pushups", "type": "compound", "muscles": ["chest"], "equipment": "bodyweight", "effectiveness": 7},
{"name": "plyo_pushups", "type": "compound", "muscles": ["chest"], "equipment": "bodyweight", "effectiveness": 8},
```

Figure 4: Chest Exercise List

```
# BACK EXERCISES
# Barbell
{"name": "barbell_deadlift", "type": "compound", "muscles": ["back"], "equipment": "barbell", "effectiveness": 10},
{"name": "barbell_row", "type": "compound", "muscles": ["back"], "equipment": "barbell", "effectiveness": 9},
{"name": "pendlay_row", "type": "compound", "muscles": ["back"], "equipment": "barbell", "effectiveness": 9},
{"name": "barbell_shrug", "type": "isolation", "muscles": ["back"], "equipment": "barbell", "effectiveness": 7},
{"name": "barbell_reverse_grip_row", "type": "compound", "muscles": ["back"], "equipment": "barbell", "effectiveness": 8},
{"name": "barbell_rack_pull", "type": "compound", "muscles": ["back"], "equipment": "barbell", "effectiveness": 8},
# Dumbbell
{"name": "dumbbell_row", "type": "compound", "muscles": ["back"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "dumbbell_reverse_fly", "type": "isolation", "muscles": ["back"], "equipment": "dumbbell", "effectiveness": 7},
{"name": "dumbbell_pullover", "type": "isolation", "muscles": ["back"], "equipment": "dumbbell", "effectiveness": 7},
{"name": "dumbbell_shrug", "type": "isolation", "muscles": ["back"], "equipment": "dumbbell", "effectiveness": 7},
{"name": "dumbbell_high_row", "type": "compound", "muscles": ["back"], "equipment": "dumbbell", "effectiveness": 7},
{"name": "dumbbell_deadlift", "type": "compound", "muscles": ["back"], "equipment": "dumbbell", "effectiveness": 8},
# Machine
{"name": "lat_pulldown", "type": "compound", "muscles": ["back"], "equipment": "machine", "effectiveness": 9},
{"name": "seated_row", "type": "compound", "muscles": ["back"], "equipment": "machine", "effectiveness": 9},
{"name": "reverse_pec_deck", "type": "isolation", "muscles": ["back"], "equipment": "machine", "effectiveness": 7},
{"name": "t-bar_row", "type": "compound", "muscles": ["back"], "equipment": "machine", "effectiveness": 8},
{"name": "machine_pullover", "type": "compound", "muscles": ["back"], "equipment": "machine", "effectiveness": 7},
{"name": "machine_shrug", "type": "isolation", "muscles": ["back"], "equipment": "machine", "effectiveness": 7},
# Cable
{"name": "straight_arm_pulldown", "type": "isolation", "muscles": ["back"], "equipment": "cable", "effectiveness": 8},
{"name": "face_pull", "type": "isolation", "muscles": ["back"], "equipment": "cable", "effectiveness": 8},
{"name": "cable_row", "type": "compound", "muscles": ["back"], "equipment": "cable", "effectiveness": 9},
{"name": "lat_pulldown", "type": "compound", "muscles": ["back"], "equipment": "cable", "effectiveness": 9},
{"name": "cable_rear_delt_fly", "type": "isolation", "muscles": ["back"], "equipment": "cable", "effectiveness": 7},
{"name": "cable_shrug", "type": "isolation", "muscles": ["back"], "equipment": "cable", "effectiveness": 7},
# Bodyweight
{"name": "pullups", "type": "compound", "muscles": ["back"], "equipment": "bodyweight", "effectiveness": 10},
{"name": "chinups", "type": "compound", "muscles": ["back"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "australian_pullups", "type": "compound", "muscles": ["back"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "archer_pullups", "type": "compound", "muscles": ["back"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "typewriter_pullups", "type": "compound", "muscles": ["back"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "towel_pullups", "type": "compound", "muscles": ["back"], "equipment": "bodyweight", "effectiveness": 8},
```

Figure 5: Back Exercise List

```
# SHOULDERS EXERCISES
# Barbell
{"name": "barbell_overhead_press", "type": "compound", "muscles": ["shoulders"], "equipment": "barbell", "effectiveness": 9},
{"name": "barbell_front_raise", "type": "isolation", "muscles": ["shoulders"], "equipment": "barbell", "effectiveness": 7},
{"name": "barbell_upright_row", "type": "compound", "muscles": ["shoulders"], "equipment": "barbell", "effectiveness": 8},
{"name": "barbell_behind_neck_press", "type": "compound", "muscles": ["shoulders"], "equipment": "barbell", "effectiveness": 7},
{"name": "barbell_landmine_press", "type": "compound", "muscles": ["shoulders"], "equipment": "barbell", "effectiveness": 8},
{"name": "barbell_shrug", "type": "isolation", "muscles": ["shoulders"], "equipment": "barbell", "effectiveness": 7},
# Dumbbell
{"name": "dumbbell_overhead_press", "type": "compound", "muscles": ["shoulders"], "equipment": "dumbbell", "effectiveness": 9},
{"name": "dumbbell_lateral_raise", "type": "isolation", "muscles": ["shoulders"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "dumbbell_front_raise", "type": "isolation", "muscles": ["shoulders"], "equipment": "dumbbell", "effectiveness": 7},
{"name": "arnold_press", "type": "compound", "muscles": ["shoulders"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "dumbbell_shrug", "type": "isolation", "muscles": ["shoulders"], "equipment": "dumbbell", "effectiveness": 7},
{"name": "dumbbell_reverse_fly", "type": "isolation", "muscles": ["shoulders"], "equipment": "dumbbell", "effectiveness": 8},
# Machine
{"name": "machine_overhead_press", "type": "compound", "muscles": ["shoulders"], "equipment": "machine", "effectiveness": 8},
{"name": "machine_lateral_raise", "type": "isolation", "muscles": ["shoulders"], "equipment": "machine", "effectiveness": 8},
{"name": "machine_rear_delt_fly", "type": "isolation", "muscles": ["shoulders"], "equipment": "machine", "effectiveness": 8},
{"name": "machine_shrug", "type": "isolation", "muscles": ["shoulders"], "equipment": "machine", "effectiveness": 7},
{"name": "machine_front_raise", "type": "isolation", "muscles": ["shoulders"], "equipment": "machine", "effectiveness": 7},
{"name": "machine_shoulder_press", "type": "compound", "muscles": ["shoulders"], "equipment": "machine", "effectiveness": 8},
# Cable
{"name": "cable_lateral_raise", "type": "isolation", "muscles": ["shoulders"], "equipment": "cable", "effectiveness": 9},
{"name": "cable_front_raise", "type": "isolation", "muscles": ["shoulders"], "equipment": "cable", "effectiveness": 8},
{"name": "cable_rear_delt_fly", "type": "isolation", "muscles": ["shoulders"], "equipment": "cable", "effectiveness": 9},
{"name": "cable_upright_row", "type": "compound", "muscles": ["shoulders"], "equipment": "cable", "effectiveness": 8},
{"name": "cable_shoulder_press", "type": "compound", "muscles": ["shoulders"], "equipment": "cable", "effectiveness": 8},
{"name": "cable_shrug", "type": "isolation", "muscles": ["shoulders"], "equipment": "cable", "effectiveness": 7},
# Bodyweight
{"name": "pike_pushup", "type": "compound", "muscles": ["shoulders"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "handstand_pushup", "type": "compound", "muscles": ["shoulders"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "wall_walk_pushup", "type": "compound", "muscles": ["shoulders"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "dive_bomber_pushup", "type": "compound", "muscles": ["shoulders"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "shoulder_tap_plank", "type": "isolation", "muscles": ["shoulders"], "equipment": "bodyweight", "effectiveness": 7},
{"name": "inverted_row", "type": "compound", "muscles": ["shoulders"], "equipment": "bodyweight", "effectiveness": 8},
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Figure 6: Shoulder Exercise List

```
# LEGS EXERCISES
# Barbell
{"name": "barbell_squat", "type": "compound", "muscles": ["quads", "glutes"], "equipment": "barbell", "effectiveness": 10},
{"name": "barbell_front_squat", "type": "compound", "muscles": ["quads"], "equipment": "barbell", "effectiveness": 9},
{"name": "barbell_deadlift", "type": "compound", "muscles": ["hamstrings", "glutes"], "equipment": "barbell", "effectiveness": 10},
{"name": "barbell_lunge", "type": "compound", "muscles": ["quads", "glutes"], "equipment": "barbell", "effectiveness": 8},
{"name": "barbell_step_up", "type": "compound", "muscles": ["quads", "glutes"], "equipment": "barbell", "effectiveness": 8},
{"name": "barbell_romanian_deadlift", "type": "isolation", "muscles": ["hamstrings"], "equipment": "barbell", "effectiveness": 9},
# Dumbbell
{"name": "dumbbell_squat", "type": "compound", "muscles": ["quads", "glutes"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "dumbbell_lunge", "type": "compound", "muscles": ["quads", "glutes"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "dumbbell_deadlift", "type": "compound", "muscles": ["hamstrings", "glutes"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "dumbbell_step_up", "type": "isolation", "muscles": ["quads", "glutes"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "dumbbell_bulgarian_split_squat", "type": "isolation", "muscles": ["quads"], "equipment": "dumbbell", "effectiveness": 9},
{"name": "dumbbell_romanian_deadlift", "type": "compound", "muscles": ["hamstrings"], "equipment": "dumbbell", "effectiveness": 8},
# Machine
{"name": "leg_press", "type": "compound", "muscles": ["quads", "glutes"], "equipment": "machine", "effectiveness": 9},
{"name": "leg_extension", "type": "isolation", "muscles": ["quads"], "equipment": "machine", "effectiveness": 8},
{"name": "leg_curl", "type": "isolation", "muscles": ["hamstrings"], "equipment": "machine", "effectiveness": 8},
{"name": "seated_leg_curl", "type": "isolation", "muscles": ["hamstrings"], "equipment": "machine", "effectiveness": 8},
{"name": "hack_squat", "type": "compound", "muscles": ["quads", "glutes"], "equipment": "machine", "effectiveness": 9},
{"name": "hip_adduction", "type": "isolation", "muscles": ["inner_thighs"], "equipment": "machine", "effectiveness": 7},
# Bodyweight
{"name": "bodyweight_squat", "type": "compound", "muscles": ["quads", "glutes"], "equipment": "bodyweight", "effectiveness": 7},
{"name": "pistol_squat", "type": "compound", "muscles": ["quads", "glutes"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "bulgarian_split_squat", "type": "compound", "muscles": ["quads"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "jump_squat", "type": "compound", "muscles": ["quads", "glutes"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "single_leg_deadlift", "type": "compound", "muscles": ["hamstrings"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "glute_bridge", "type": "compound", "muscles": ["glutes"], "equipment": "bodyweight", "effectiveness": 8},
```

Figure 7: Leg Exercise List

```
# ARMS EXERCISES (Biceps/Triceps)
# Barbell
{"name": "barbell_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "barbell", "effectiveness": 8},
{"name": "barbell_preacher_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "barbell", "effectiveness": 9},
{"name": "barbell_reverse_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "barbell", "effectiveness": 7},
{"name": "barbell_close_grip_bench", "type": "compound", "muscles": ["triceps"], "equipment": "barbell", "effectiveness": 9},
{"name": "barbell_skullcrusher", "type": "isolation", "muscles": ["triceps"], "equipment": "barbell", "effectiveness": 9},
{"name": "barbell_overhead_triceps", "type": "isolation", "muscles": ["triceps"], "equipment": "barbell", "effectiveness": 8},
# Dumbbell
{"name": "dumbbell_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "hammer_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "concentration_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "dumbbell", "effectiveness": 9},
{"name": "dumbbell_triceps_extension", "type": "isolation", "muscles": ["triceps"], "equipment": "dumbbell", "effectiveness": 8},
{"name": "dumbbell_kickback", "type": "isolation", "muscles": ["triceps"], "equipment": "dumbbell", "effectiveness": 7},
{"name": "dumbbell_overhead_triceps", "type": "isolation", "muscles": ["triceps"], "equipment": "dumbbell", "effectiveness": 9},
# Machine
{"name": "machine_preacher_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "machine", "effectiveness": 8},
{"name": "machine_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "machine", "effectiveness": 8},
{"name": "machine_concentration_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "machine", "effectiveness": 8},
{"name": "machine_triceps_extension", "type": "isolation", "muscles": ["triceps"], "equipment": "machine", "effectiveness": 8},
{"name": "machine_dip", "type": "compound", "muscles": ["triceps"], "equipment": "machine", "effectiveness": 9},
{"name": "machine_triceps_pushdown", "type": "isolation", "muscles": ["triceps"], "equipment": "machine", "effectiveness": 8},
# Cable
{"name": "cable_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "cable", "effectiveness": 9},
{"name": "cable_preacher_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "cable", "effectiveness": 9},
{"name": "cable_hammer_curl", "type": "isolation", "muscles": ["biceps"], "equipment": "cable", "effectiveness": 8},
{"name": "cable_triceps_pushdown", "type": "isolation", "muscles": ["triceps"], "equipment": "cable", "effectiveness": 9},
{"name": "cable_overhead_extension", "type": "isolation", "muscles": ["triceps"], "equipment": "cable", "effectiveness": 9},
{"name": "cable_kickback", "type": "isolation", "muscles": ["triceps"], "equipment": "cable", "effectiveness": 8},
# Bodyweight
{"name": "chinup", "type": "compound", "muscles": ["biceps"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "dips", "type": "compound", "muscles": ["triceps"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "diamond_pushup", "type": "compound", "muscles": ["triceps"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "close_grip_pushup", "type": "compound", "muscles": ["triceps"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "inverted_row", "type": "compound", "muscles": ["biceps"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "bodyweight_triceps_extension", "type": "isolation", "muscles": ["triceps"], "equipment": "bodyweight", "effectiveness": 7},
```

Figure 8: Arm Exercise List

```
# CORE EXERCISES
# Bodyweight
{"name": "plank", "type": "isolation", "muscles": ["core"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "side_plank", "type": "isolation", "muscles": ["core"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "hanging_leg_raise", "type": "isolation", "muscles": ["core"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "russian_twist", "type": "isolation", "muscles": ["core"], "equipment": "bodyweight", "effectiveness": 7},
{"name": "ab_wheel_rollout", "type": "isolation", "muscles": ["core"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "l_sit", "type": "isolation", "muscles": ["core"], "equipment": "bodyweight", "effectiveness": 9},

# Weighted
{"name": "cable_woodchopper", "type": "isolation", "muscles": ["core"], "equipment": "cable", "effectiveness": 8},
{"name": "cable_crunch", "type": "isolation", "muscles": ["core"], "equipment": "cable", "effectiveness": 8},
{"name": "weighted_plank", "type": "isolation", "muscles": ["core"], "equipment": "weighted", "effectiveness": 8},
{"name": "weighted_situp", "type": "isolation", "muscles": ["core"], "equipment": "weighted", "effectiveness": 7},
{"name": "weighted_leg_raise", "type": "isolation", "muscles": ["core"], "equipment": "weighted", "effectiveness": 8},
{"name": "weighted_russian_twist", "type": "isolation", "muscles": ["core"], "equipment": "weighted", "effectiveness": 8},

{"name": "outdoor_running", "type": "steady_state", "muscles": ["legs", "core"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "treadmill_running", "type": "steady_state", "muscles": ["legs", "core"], "equipment": "treadmill", "effectiveness": 9},
{"name": "trail_running", "type": "interval", "muscles": ["legs", "core"], "equipment": "bodyweight", "effectiveness": 10},
{"name": "hill_running", "type": "interval", "muscles": ["legs", "glutes"], "equipment": "bodyweight", "effectiveness": 10},
{"name": "sprint_intervals", "type": "hiit", "muscles": ["legs", "core"], "equipment": "bodyweight", "effectiveness": 10},
{"name": "fartlek_training", "type": "interval", "muscles": ["legs", "core"], "equipment": "bodyweight", "effectiveness": 9},
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Figure 9: Core Exercise List

```
# CARDIO
# CYCLING
{"name": "outdoor_cycling", "type": "steady_state", "muscles": ["legs", "glutes"], "equipment": "bicycle", "effectiveness": 8},
{"name": "stationary_bike", "type": "steady_state", "muscles": ["legs", "glutes"], "equipment": "stationary_bike", "effectiveness": 8},
{"name": "spin_class", "type": "interval", "muscles": ["legs", "glutes"], "equipment": "spin_bike", "effectiveness": 9},
{"name": "indoor_cycling_intervals", "type": "hiit", "muscles": ["legs", "glutes"], "equipment": "stationary_bike", "effectiveness": 9},
{"name": "hill_cycling", "type": "interval", "muscles": ["legs", "glutes"], "equipment": "bicycle", "effectiveness": 9},
{"name": "recumbent_bike", "type": "steady_state", "muscles": ["legs"], "equipment": "recumbent_bike", "effectiveness": 7},

# ROWING
{"name": "rowing_machine", "type": "steady_state", "muscles": ["legs", "back", "arms"], "equipment": "rower", "effectiveness": 10},
{"name": "rowing_intervals", "type": "hiit", "muscles": ["legs", "back", "arms"], "equipment": "rower", "effectiveness": 10},
{"name": "outdoor_rowing", "type": "steady_state", "muscles": ["legs", "back", "arms"], "equipment": "rowing_boat", "effectiveness": 9},
{"name": "sprint_rows", "type": "hiit", "muscles": ["legs", "back", "arms"], "equipment": "rower", "effectiveness": 10},
{"name": "endurance_rows", "type": "steady_state", "muscles": ["legs", "back", "arms"], "equipment": "rower", "effectiveness": 9},
{"name": "power_rows", "type": "interval", "muscles": ["legs", "back", "arms"], "equipment": "rower", "effectiveness": 9},

# STAIR/STEP
{"name": "stair_climbing", "type": "steady_state", "muscles": ["legs", "glutes"], "equipment": "stairs", "effectiveness": 9},
{"name": "stair_machine", "type": "steady_state", "muscles": ["legs", "glutes"], "equipment": "stairmill", "effectiveness": 9},
{"name": "step_aerobics", "type": "interval", "muscles": ["legs", "glutes"], "equipment": "step_platform", "effectiveness": 8},
{"name": "stair_intervals", "type": "hiit", "muscles": ["legs", "glutes"], "equipment": "stairs", "effectiveness": 10},
{"name": "box_step_ups", "type": "interval", "muscles": ["legs", "glutes"], "equipment": "box", "effectiveness": 8},
{"name": "stadium_stairs", "type": "interval", "muscles": ["legs", "glutes"], "equipment": "stairs", "effectiveness": 10},

# JUMPING/PLYOMETRICS
{"name": "jump_rope", "type": "hiit", "muscles": ["legs", "core"], "equipment": "jump_rope", "effectiveness": 10},
{"name": "box_jumps", "type": "hiit", "muscles": ["legs", "glutes"], "equipment": "box", "effectiveness": 9},
{"name": "burpees", "type": "hiit", "muscles": ["full_body"], "equipment": "bodyweight", "effectiveness": 10},
{"name": "jumping_jacks", "type": "hiit", "muscles": ["legs", "shoulders"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "plyometric_lunges", "type": "hiit", "muscles": ["legs", "glutes"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "depth_jumps", "type": "hiit", "muscles": ["legs", "glutes"], "equipment": "box", "effectiveness": 9},

# SWIMMING
{"name": "freestyle_swimming", "type": "steady_state", "muscles": ["full_body"], "equipment": "pool", "effectiveness": 10},
{"name": "breaststroke", "type": "steady_state", "muscles": ["full_body"], "equipment": "pool", "effectiveness": 9},
{"name": "swim_intervals", "type": "hiit", "muscles": ["full_body"], "equipment": "pool", "effectiveness": 10},
{"name": "backstroke", "type": "steady_state", "muscles": ["full_body"], "equipment": "pool", "effectiveness": 8},
{"name": "butterfly", "type": "interval", "muscles": ["full_body"], "equipment": "pool", "effectiveness": 10},
{"name": "water_aerobics", "type": "steady_state", "muscles": ["full_body"], "equipment": "pool", "effectiveness": 7},
```

Figure 10: Cardio Exercise List 1

```
# ELLIPTICAL/CROSS-TRAINER
{"name": "elliptical_machine", "type": "steady_state", "muscles": ["legs", "glutes"], "equipment": "elliptical", "effectiveness": 8},
{"name": "elliptical_intervals", "type": "hiit", "muscles": ["legs", "glutes"], "equipment": "elliptical", "effectiveness": 9},
{"name": "cross_trainer", "type": "steady_state", "muscles": ["legs", "glutes"], "equipment": "cross_trainer", "effectiveness": 8},
{"name": "reverse_elliptical", "type": "steady_state", "muscles": ["hamstrings", "glutes"], "equipment": "elliptical", "effectiveness": 8},
{"name": "ramp_elliptical", "type": "interval", "muscles": ["legs", "glutes"], "equipment": "elliptical", "effectiveness": 9},
{"name": "resistance_elliptical", "type": "interval", "muscles": ["legs", "glutes"], "equipment": "elliptical", "effectiveness": 9},

# KETTLEBELL
{"name": "kettlebell_swings", "type": "hiit", "muscles": ["quads","hamstrings", "glutes", "core"], "equipment": "kettlebell", "effectiveness": 10},
{"name": "kettlebell_circuit", "type": "hiit", "muscles": ["full_body"], "equipment": "kettlebell", "effectiveness": 10},
{"name": "kettlebell_jacks", "type": "hiit", "muscles": ["full_body"], "equipment": "kettlebell", "effectiveness": 9},
{"name": "kettlebell_step_ups", "type": "interval", "muscles": ["quads", "glutes"], "equipment": "kettlebell", "effectiveness": 8},
{"name": "kettlebell_clean_press", "type": "hiit", "muscles": ["full_body"], "equipment": "kettlebell", "effectiveness": 9},
{"name": "kettlebell_snatches", "type": "hiit", "muscles": ["full_body"], "equipment": "kettlebell", "effectiveness": 10},

# BODYWEIGHT CIRCUITS
{"name": "tabata_squats", "type": "hiit", "muscles": ["quads","hamstrings", "glutes"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "mountain_climbers", "type": "hiit", "muscles": ["core", "quads"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "high_knees", "type": "hiit", "muscles": ["quads", "core"], "equipment": "bodyweight", "effectiveness": 8},
{"name": "speed_skaters", "type": "hiit", "muscles": ["glutes"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "bear_crawls", "type": "hiit", "muscles": ["full_body"], "equipment": "bodyweight", "effectiveness": 9},
{"name": "squat_thrusts", "type": "hiit", "muscles": ["full_body"], "equipment": "bodyweight", "effectiveness": 9},

# SPECIALTY
{"name": "battle_ropes", "type": "hiit", "muscles": ["arms", "shoulders", "core"], "equipment": "ropes", "effectiveness": 9},
{"name": "sled_pulls", "type": "hiit", "muscles": ["quads","hamstrings","glutes", "back"], "equipment": "sled", "effectiveness": 9},
{"name": "farmer_walks", "type": "steady_state", "muscles": ["arms", "core"], "equipment": "dumbbells", "effectiveness": 8}
```

Figure 11: Cardio Exercise List 2

Appendix B: Plan Outlines

```
two_day_full_body = {
    "name": "2-Day Full Body",
    "goal": "maintain",
    "level": "beginner",
    "day_count": 2,
    "days": {
        "Day 1": {
            "focus": ["chest", "back", "legs"],
            "max_compounds": 3,
            "max_exercises": 4
        },
        "Day 2": {
            "focus": ["shoulders", "arms", "hamstrings"],
            "max_compounds": 2,
            "max_exercises": 4
        }
    }
}
```

Figure 12: 2-Day Full-Body

```
two_day_metabolic = {
    "name": "2-Day Metabolic",
    "goal": "fat loss",
    "level": "Beginner",
    "day_count": 2,
    "days": {
        "Day 1 (Strength + Metabolic)": {
            "focus": ["chest", "back", "legs"],
            "max_compounds": 3,
            "max_exercises": 4,
            "cardio": {"type": ["hiit", "interval", "circuit","full_body"]}
        },
        "Day 2 (Core + Endurance)": {
            "focus": ["core"],
            "max_compounds": 2,
            "max_exercises": 3,
            "cardio": {"type": ["steady_state", "full_body"]}
        }
    }
}
```

Figure 13: 2-Day Metabolic

```
two_day_str_body = {
    "name": "2-Day Full Body",
    "goal": "gain muscle",
    "level": "beginner",
    "day_count": 2,
    "days": {
        "Day 1": {
            "focus": ["chest", "back", "core"],
            "max_compounds": 3,
            "max_exercises": 4
        },
        "Day 2": {
            "focus": ["back","shoulders","legs"],
            "max_compounds": 3,
            "max_exercises": 4
        }
    }
}
```

Figure 14: 2-Day Full-Body with Strength Focus

```
three_day_metabolic = {
    "name": "3-Day Metabolic Accelerator",
    "goal": "fat loss",
    "level": "Intermediate",
    "day_count": 3,
    "days": {
        "Day 1 (Upper Body Power)": {
            "focus": ["chest", "back", "shoulders"],
            "max_compounds": 3,
            "max_exercises": 5,
            "cardio": {"type": ["hiit", "circuit","full_body"]}
        },
        "Day 2 (Lower Body Complex)": {
            "focus": ["quads", "hamstrings", "glutes"],
            "max_compounds": 3,
            "max_exercises": 6,
            "cardio": {"type": ["interval", "full_body"]}
        },
        "Day 3 (Total Body Metabolic)": {
            "focus": ["core", "arms"],
            "max_compounds": 1,
            "max_exercises": 5,
            "cardio": {"type": ["circuit", "steady_state","full_body"]}
        }
    }
}
```

Figure 15: 3-Day Metabolic

```
three_day_ppl = {
    "name": "3-Day PPL",
    "goal": "gain muscle",
    "level": "Beginner",
    "day_count": 3,
    "days": {
        "Day 1": {
            "focus": ["chest", "shoulders", "triceps"],
            "max_compounds": 2,
            "max_exercises": 5
        },
        "Day 2": {
            "focus": ["back", "biceps", "core"],
            "max_compounds": 2,
            "max_exercises": 5
        },
        "Day 3": {
            "focus": ["quads", "glutes", "hamstrings", "calves"],
            "max_compounds": 2,
            "max_exercises": 5
        }
    }
}
```

Figure 16: 3-Day Push-Pull-Legs

```
four_day_upper_lower = {
    "name": "4-Day Upper/Lower",
    "goal": "maintain",
    "level": "intermediate",
    "day_count": 4,
    "days": {
        "Upper A": {
            "focus": ["chest", "back", "shoulders", "triceps"],
            "max_compounds": 2,
            "max_exercises": 5
        },
        "Lower A": {
            "focus": ["quads", "hamstrings", "glutes"],
            "max_compounds": 2,
            "max_exercises": 5
        },
        "Upper B": {
            "focus": ["back", "shoulders", "biceps"],
            "max_compounds": 2,
            "max_exercises": 5
        },
        "Lower B": {
            "focus": ["glutes", "hamstrings", "calves"],
            "max_compounds": 1,
            "max_exercises": 5
        }
    }
}
```

Figure 17: 4-Day Upper/Lower

```
four_day_metabolic = {
    "name": "4-Day Metabolic Split",
    "goal": "fat loss",
    "level": "Intermediate",
    "day_count": 4,
    "days": {
        "Day 1 (Push + Power)": {
            "focus": ["chest", "shoulders", "triceps"],
            "max_compounds": 2,
            "max_exercises": 5,
            "cardio": {"type": ["hiit", "interval","full_body"]}
        },
        "Day 2 (Pull + Endurance)": {
            "focus": ["back", "biceps"],
            "max_compounds": 2,
            "max_exercises": 5,
            "cardio": {"type": ["steady_state", "full_body"]}
        },
        "Day 3 (Legs + Complex)": {
            "focus": ["quads", "hamstrings", "glutes"],
            "max_compounds": 3,
            "max_exercises": 6,
            "cardio": {"type": ["interval", "circuit","full_body"]}
        },
        "Day 4 (Metabolic Finisher)": {
            "focus": ["core", "full_body"],
            "max_compounds": 1,
            "max_exercises": 8,
            "cardio": {"type": ["circuit", "hiit","full_body"]}
        }
    }
}
```

Figure 18: 4-Day Metabolic

```
four_day_bodybuilding = {
    "name": "4-Day Advanced Bodybuilding",
    "goal": "gain muscle",
    "level": "advanced",
    "day_count": 4,
    "days": {
        "Upper A (Push Focus)": {
            "focus": ["chest", "shoulders", "triceps"],
            "max_compounds": 3,
            "max_exercises": 5
        },
        "Lower A (Quad Dominant)": {
            "focus": ["quads", "glutes", "core"],
            "max_compounds": 3,
            "max_exercises": 5
        },
        "Upper B (Pull Focus)": {
            "focus": ["back", "biceps", "rear delts"],
            "max_compounds": 3,
            "max_exercises": 5
        },
        "Lower B (Hamstring Dominant)": {
            "focus": ["hamstrings", "glutes", "calves", "core"],
            "max_compounds": 3,
            "max_exercises": 5
        }
    }
}
```

Figure 19: 4-Day Bodybuilding

```
five_day_ppl = {
    "name": "5-Day PPL",
    "description": "Targeted Muscle Growth",
    "level": "intermediate",
    "day_count": 5,
    "days": {
        "Push A": {
            "focus": ["chest", "shoulders", "triceps"],
            "max_compounds": 2,
            "max_exercises": 5
        },
        "Pull B": {
            "focus": ["back", "biceps"],
            "max_compounds": 2,
            "max_exercises": 5,
        },
        "Legs": {
            "focus": ["quads", "hamstrings", "glutes", "core"],
            "max_compounds": 3,
            "max_exercises": 5
        },
        "Push B": {
            "focus": ["chest", "shoulders", "triceps"],
            "max_compounds": 1,
            "max_exercises": 4
        },
        "Pull B": {
            "focus": ["back", "biceps"],
            "max_compounds": 1,
            "max_exercises": 4
        }
    }
}
```

Figure 20: 5-Day Push-Pull-Legs

```
five_day_bro_split = {
    "name": "5-Day Bro Split",
    "goal": "gain muscle",
    "level": "beginner",
    "day_count": 5,
    "days": {
        "Chest": {
            "focus": ["chest"],
            "max_compounds": 1,
            "max_exercises": 3
        },
        "Back": {
            "focus": ["back"],
            "max_compounds": 1,
            "max_exercises": 3
        },
        "Shoulders": {
            "focus": ["shoulders"],
            "max_compounds": 1,
            "max_exercises": 3
        },
        "Legs": {
            "focus": ["quads","hamstrings","glutes","calves"],
            "max_compounds": 2,
            "max_exercises": 4
        },
        "Arms": {
            "focus": ["biceps", "triceps"],
            "max_compounds": 1,
            "max_exercises": 3
        }

    }
}
```

Figure 21: 5-Day Bro Split

```
five_day_metabolic = {
    "name": "5-Day Metabolic Conditioning",
    "goal": "fat loss",
    "level": "Advanced",
    "day_count": 5,
    "days": {
        "Day 1 (Upper Strength)": {
            "focus": ["chest", "back"],
            "max_compounds": 3,
            "max_exercises": 5,
            "cardio": {"type": ["hiit", "interval","full_body"]}
        },
        "Day 2 (Lower Power)": {
            "focus": ["quads", "glutes"],
            "max_compounds": 3,
            "max_exercises": 5,
            "cardio": {"type": ["interval", "full_body"]}
        },
        "Day 3 (Upper Hypertrophy)": {
            "focus": ["shoulders", "arms"],
            "max_compounds": 2,
            "max_exercises": 5,
            "cardio": {"type": ["circuit", "hiit","full_body"]}
        },
        "Day 4 (Lower Endurance)": {
            "focus": ["hamstrings", "glutes"],
            "max_compounds": 2,
            "max_exercises": 5,
            "cardio": {"type": ["steady_state", "full_body"]}
        },
        "Day 5 (Metabolic Storm)": {
            "focus": ["core", "full_body"],
            "max_compounds": 1,
            "max_exercises": 6,
            "cardio": {"type": ["circuit", "interval", "hiit"]}
        }
    }
}
```

Figure 22: 5-Day Metabolic

```
six_day_ppl = {
    "name": "6-Day PPL",
    "goal": "gain muscle",
    "level": "advanced",
    "day_count": 6,
    "days": {
        "Push A": {
            "focus": ["chest", "shoulders", "triceps"],
            "max_compounds": 2,
            "max_exercises": 5,
        },
        "Pull A": {
            "focus": ["back", "biceps"],
            "max_compounds": 2,
            "max_exercises": 5,
        },
        "Legs A": {
            "focus": ["quads", "hamstrings", "glutes"],
            "max_compounds": 3,
            "max_exercises": 5
        },
        "Push B": {
            "focus": ["chest", "shoulders", "triceps"],
            "max_compounds": 1,
            "max_exercises": 5
        },
        "Pull B": {
            "focus": ["back", "biceps"],
            "max_compounds": 1,
            "max_exercises": 5
        },
        "Legs B": {
            "focus": ["glutes", "hamstrings", "calves"],
            "max_compounds": 2,
            "max_exercises": 5
        }
    }
}
```

Figure 23: 6-Day Push-Pull-Legs

```
six_day_metabolic = {
    "name": "6-Day Metabolic Intensive",
    "goal": "fat loss",
    "level": "Advanced",
    "day_count": 6,
    "days": {
        "Day 1 (Push Power)": {
            "focus": ["chest", "shoulders", "triceps"],
            "max_compounds": 3,
            "max_exercises": 5,
            "cardio": {"type": ["hiit", "interval","full_body"]}
        },
        "Day 2 (Pull Strength)": {
            "focus": ["back", "biceps"],
            "max_compounds": 3,
            "max_exercises": 5,
            "cardio": {"type": ["interval", "circuit","full_body"]}
        },
        "Day 3 (Legs Complex)": {
            "focus": ["quads", "glutes"],
            "max_compounds": 3,
            "max_exercises": 5,
            "cardio": {"type": ["circuit", "full_body"]}
        },
        "Day 4 (Upper Metabolic)": {
            "focus": ["chest", "back", "arms"],
            "max_compounds": 1,
            "max_exercises": 6,
            "cardio": {"type": ["circuit", "hiit","full_body"]}
        },
        "Day 5 (Lower Endurance)": {
            "focus": ["hamstrings", "glutes", "core"],
            "max_compounds": 2,
            "max_exercises": 5,
            "cardio": {"type": ["interval", "steady_state","full_body"]}
        },
        "Day 6 (Total Annihilation)": {
            "focus": ["full_body"],
            "max_compounds": 1,
            "max_exercises": 7,
            "cardio": {"type": ["circuit", "hiit", "full_body"]}
        }
    }
}
```

Figure 24: 6-Day Metabolic