

Key Points on Exercise Detection with MediaPipe

- **Bicep Curl:** Research suggests reliable detection via elbow angle tracking (shoulder-elbow-wrist), with stages defined by angles above 160° (down) and below 35° (up); constraints like torso stability help minimize false positives from casual arm movements.
- **Kick (Assuming Front Kick):** Evidence leans toward using leg and hip angles (ankle-knee-hip $>120^\circ$, shoulder-hip-knee $71\text{-}120^\circ$), with phased detection ("in" to "out") to distinguish from walking or stretching.
- **Lunges:** It seems likely that knee angles around 90° for both legs, combined with position checks (e.g., back knee low), reduce errors; asymmetry in leg placement is key to avoid confusing with squats.
- **Plank:** The evidence points to body alignment angles near 180° (shoulder-hip-ankle) for straight posture, with duration thresholds to filter brief poses; stability over frames prevents misdetection during transitions.

These detections rely on MediaPipe's 33 pose landmarks for real-time tracking in your Android app. Implement angle calculations using vector dot products, and apply confidence thresholds (>0.5) across exercises to enhance accuracy.

Implementation Basics

MediaPipe Pose provides landmarks like shoulders (11/12), elbows (13/14), wrists (15/16), hips (23/24), knees (25/26), and ankles (27/28). Calculate angles with code like:

```
python
```

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```
import numpy as np
def calculate_angle(a, b, c):
    a = np.array(a) # First point
    b = np.array(b) # Mid point
    c = np.array(c) # End point
    radians = np.arctan2(c[1]-b[1], c[0]-b[0]) - np.arctan2(a[1]-b[1], a[0])
    angle = np.abs(radians * 180.0 / np.pi)
    if angle > 180.0: angle = 360 - angle
    return angle
```

Use visibility and presence scores from landmarks to filter noisy data.

Reducing False Positives Overall

- Apply temporal smoothing (e.g., average over 5-10 frames) to ignore jitter.
- Require sequence matching: Detect full cycles (e.g., down-up for curls) rather than isolated poses.
- Add body orientation checks: Ensure upright torso (shoulder-hip angle $\sim 180^\circ$) and minimal unrelated limb movement.
- Use confidence thresholds and multi-frame confirmation (e.g., 20-30 frames for static poses like plank).

For Android integration, use MediaPipe's Pose Landmarker task via the Java API, processing camera frames in real-time.

Comprehensive Guide to Exercise Detection Constraints and Angles Using MediaPipe

This section provides a detailed overview of detecting the specified exercises (Bicep Curl,

Kick, Lunges, Plank) with MediaPipe Pose in an Android app. MediaPipe's pose estimation infers 33 3D landmarks from RGB frames, enabling angle calculations and position checks. The focus is on key angles, thresholds, and constraints to minimize false positives, drawn from analyzed sources on pose-based fitness tracking. False positives are reduced by combining angular thresholds with positional constraints, confidence filtering, and temporal consistency checks.

MediaPipe Pose Fundamentals

MediaPipe Pose tracks 33 landmarks (0-32), with relevant ones for these exercises including:

- Upper body: left_shoulder (11), right_shoulder (12), left_elbow (13), right_elbow (14), left_wrist (15), right_wrist (16).
- Lower body: left_hip (23), right_hip (24), left_knee (25), right_knee (26), left_ankle (27), right_ankle (28). Landmarks provide x, y, z coordinates (normalized or world-scale), visibility (0-1), and presence (0-1). Filter detections with visibility <0.5 or presence <0.5 to avoid noise. Angles are computed using the arctan2-based formula for three points, as shown earlier.

To integrate in Android:

- Use the PoseLandmarker class from MediaPipe Tasks SDK.
- Process ImageProxy from CameraX in a Analyzer, extracting landmarks per frame.
- Apply constraints in a custom detector class to flag exercises and count reps.

Bicep Curl Detection

Bicep curls involve arm flexion, tracked primarily via elbow angle changes. Sources emphasize real-time counting with stages to ensure full range of motion.

Key Angles and Calculations:

- Elbow angle: Between shoulder-elbow and elbow-wrist vectors (e.g., points 11-13-15 for left arm).
- Secondary: Torso-upper arm angle (shoulder-hip-elbow) for form check.

Thresholds and Stages:

- Down stage: Elbow angle $>160^\circ$ (arm extended).
- Up stage: Elbow angle $<35^\circ$ (arm flexed).
- Rep count: Increment on transition from down to up, only if full cycle completed (e.g., angle decreases below 70° during contraction).
- Form thresholds: Torso-upper arm $<35^\circ$ (avoids swinging); upper arm-forearm $<70^\circ$ for complete rep.

Constraints to Reduce False Positives:

- Confidence: Landmark visibility >0.5 ; discard if <0.5 for 3+ frames.
- Temporal: Smooth angles over 5 frames; require 10-frame consistency for stage changes.
- Positional: Torso upright (shoulder-hip angle $\sim 180^\circ \pm 10^\circ$); minimal hip movement (hip y-variation $<5\%$).
- Other: Check bilateral symmetry if both arms; ignore if legs moving (knee angle variation $>10^\circ$).
- Accuracy notes: Reported 96% rep quantification accuracy with these; false positives from occlusion reduced via redundant landmarks (e.g., approximate elbow from shoulder-wrist if occluded).

| Aspect | Left Arm Landmarks | Right Arm Landmarks | Threshold Range | Purpose |
|---------------------------|-----------------------|------------------------|---------------------------------------|-----------------|
| Elbow Angle | 11-13-15 | 12-14-16 | $>160^\circ$ (down), $<35^\circ$ (up) | Stage detection |
| Torso-Arm Angle | 11-23-13 | 12-24-14 | $<35^\circ$ | Form validation |
| Shoulder-Hip Alignment | 11-23 | 12-24 | $\sim 180^\circ \pm 10^\circ$ | Upright check |

Kick Detection (Focusing on Front Kick)

Front kicks involve leg extension, with sources highlighting phased movement to

distinguish from similar actions like steps.

Key Angles and Calculations:

- Leg angle: Ankle-knee-hip (e.g., 27-25-23 for left).
- Hip angle: Shoulder-hip-knee (11-23-25).

Thresholds and Stages:

- "In" stage (prep): Leg angle $<110^\circ$, hip angle $>130^\circ$.
- "Out" stage (extension): Leg angle $>120^\circ$, hip angle 71-120°.
- Detection trigger: Transition from "in" to "out" with angle increase $>50^\circ$ in <1 second.
- Form thresholds: Leg $>110^\circ$ for correct; hip $<130^\circ$ to avoid back strain.

Constraints to Reduce False Positives:

- Confidence: Knee/ankle visibility >0.6 ; filter geo-occluded frames.
- Temporal: Require sequence over 15-20 frames; velocity of ankle ($dy/dt >$ threshold) for dynamic kick.
- Positional: Opposite leg stable (knee angle variation $<5^\circ$); torso upright (shoulder-hip $\sim 180^\circ$).
- Other: Ignore if both legs moving symmetrically (e.g., jumping); min score threshold 0.18 for semantic match.
- Accuracy notes: Heuristics from gym assistants reduce misdetections by 20-30% vs. angle-only.

| Aspect | Left Leg Landmarks | Right Leg Landmarks | Threshold Range | Purpose | ⋮ |
|--------|-----------------------|------------------------|-----------------|---------|---|
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|-----------------|----------|----------|-------------------------|-----------------|
| Leg Angle | 27-25-23 | 28-26-24 | >120° (out), <110° (in) | Extension check |
| Hip Angle | 11-23-25 | 12-24-26 | 71-120° | Form validation |
| Torso Alignment | 11-23 | 12-24 | ~180° ±15° | Stability |

Lunges Detection

Lunges are asymmetric lower-body movements, with sources noting knee-over-toe errors as common false positive triggers.

Key Angles and Calculations:

- Front knee angle: Hip-knee-ankle (e.g., 23-25-27).
- Back knee angle: Similar for back leg.
- Torso angle: Shoulder-hip (11-23).

Thresholds and Stages:

- Lunge position: Front knee ~90° ±20°, back knee ~90° ±20°.
- Depth: Back knee y-coordinate >0.8 * hip y (close to ground).
- Rep count: Cycle from standing (knees >160°) to lunge and back.

Constraints to Reduce False Positives:

- Confidence: Leg landmarks >0.5; multi-frame average.
- Temporal: 20-frame confirmation; detect step sequence (foot x-difference > hip width).
- Positional: Knee not over toe (knee x < ankle x + 0.1 normalized); torso upright (~180°).
- Other: Asymmetric legs (one forward); ignore if symmetric (e.g., squat-like).
- Accuracy notes: Similar to squats, with 85-95% form detection; reduces confusion with walks via depth check.

| Aspect | Front Leg (Left) | Back Leg (Right) | Threshold Range | Purpose | ⋮ |
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|---------------|------------------|------------------|-------------------------------|-----------------|
| Knee Angle | 23-25-27 | 24-26-28 | $\sim 90^\circ \pm 20^\circ$ | Bend validation |
| Torso Angle | 11-23 | 12-24 | $\sim 180^\circ \pm 10^\circ$ | Upright check |
| Knee Position | Knee y vs. hip y | Knee y vs. hip y | $>0.8 * \text{hip y (back)}$ | Depth |

Plank Detection

Plank is static, focused on alignment; sources use multi-frame consistency to avoid transient poses.

Key Angles and Calculations:

- Body alignment: Shoulder-hip-ankle (11-23-27).
- Knee straightness: Hip-knee-ankle (23-25-27).
- Angle with horizontal: Line (shoulder-ankle) vs. x-axis.

Thresholds and Stages:

- Alignment: $\sim 180^\circ \pm 10^\circ$ (straight body).
- Horizontal: Angle with x-axis $\sim 0^\circ \pm 5^\circ$ (or 90° if side view).
- Detection: Hold for >24 frames; timer starts on match.

Constraints to Reduce False Positives:

- Confidence: Core landmarks >0.6 ; discard if variation $>5\%$.
- Temporal: Mean angle difference <5 over 24 frames; no movement (position std <0.05).
- Positional: Elbows under shoulders (elbow x \sim shoulder x); feet/shoulders level.
- Other: Differentiate from pushups via no up-down cycle; min duration 5 seconds.
- Accuracy notes: 90%+ for static poses; false positives drop with frame count.

| Aspect | Left Side Landmarks | Right Side Landmarks | Threshold Range | Purpose |
|--------|---------------------|----------------------|-----------------|---------|
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|------------------|--------------------|--------------------|-------------------------------|--------------|
| Alignment Angle | 11-23-27 | 12-24-28 | $\sim 180^\circ \pm 10^\circ$ | Straightness |
| Horizontal Angle | 11-27 (vs. x-axis) | 12-28 (vs. x-axis) | $\sim 0^\circ \pm 5^\circ$ | Orientation |
| Knee Angle | 23-25-27 | 24-26-28 | $\sim 180^\circ \pm 10^\circ$ | Leg straight |

These setups can be coded as state machines in your app, with audio/visual feedback. Test with varied lighting/camera angles for robustness.

Key Citations

- Real-Time Bicep Curl Tracking and Pose Detection Using OpenCV [ijarit.com](#)
- Assessing Bicep Curl Exercises by Human Pose Application [researchgate.net](#)
- REVOLUTIONIZING FITNESS ROUTINES USING MEDIAPIPE [irjmets.com](#)
- Pose Estimation and Virtual Gym Assistant Using MediaPipe [researchgate.net](#)
- An Easy Guide for Pose Estimation with Google's MediaPipe [logessiva.medium.com](#)
- AI Fitness Trainer Using MediaPipe For Squat Analysis [learnopencv.com](#)
- Exercise-Correction GitHub Repo [github.com](#)